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1986

HAMILTON AIR QUALITY

April 1988

Ontario Ministry of the Environment

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West Central Region

1986 HAMILTON AIR QUALITY

F. DOBROFF
MINISTRY OF THE ENVIRONMENT
WEST CENTRAL REGION

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RÉSUMÉ

La présente étude sur la qualité de l'air à Hamilton, effectuée en 1986, révèle que les concentrations de particules en suspension dans l'air et de composés de soufre malodorants ne respectaient toujours pas les objectifs du MEO sur la qualité de l'air ambiant. La région la plus touchée est la zone industrielle d'Hamilton. Mais en cas d'inversion météorologique, la pollution s'étend à toute la ville. C'est ainsi qu'à cinq reprises, l'Indice de pollution atmosphérique a dépassé le critère souhaitable de 32.

On a mesuré les concentrations de fluorures à l'unique briqueterie de la ville et on a constaté qu'elles étaient bien au-dessus des objectifs établis. Les concentrations relevées lors de l'évaluation phytotoxicologique annuelle ne présentaient aucun danger pour la santé des humains. On a détecté toutefois des dommages à la végétation poussant près de la briqueterie. Le Ministère effectuera donc à la briqueterie une enquête sur ses sources de pollution. De plus, l'étude révèle que la pollution atmosphérique dans la zone industrielle a causé de légers dommages à la végétation fragile. On n'en a relevé nulle part ailleurs.

Au cours d'une étude effectuée par l'unité mobile de surveillance de l'air de la Direction des ressources atmosphériques, on a mesuré des concentrations notables de soufre total réduit et de naphtalène sous le vent du complexe industriel Domtar (usine Cassidy). On a également constaté que la société Stelco était une source importante d'oxydes d'azote.

Les principales industries d'Hamilton ont mis sur pied des programmes de réduction des concentrations de particules et des émanations malodorantes. Il faudrait également s'occuper des émanations provenant de sources fugitives non industrielles, telles que la poussière des chemins. On préconise de mettre sur pied des programmes pour nettoyer les chemins et pour empêcher d'amener de la terre sur les routes. Il serait également essentiel de réduire davantage les émanations de sources industrielles fugitives, notamment, les poussières dégagées des matériaux empilés et de sources autres que les cheminées.

1. SUMMARY

Air quality in Hamilton in 1986 changed little from the previous year.

The Air Pollution Index reached the advisory level of 32 five times in 1986 compared to 2 occasions in 1985.

The network of high volume samplers measuring suspended particulates generally showed slightly higher levels in 1986 than in the previous year, due possibly to an increase in long range transport of pollutants to the City.

Dustfall jars located throughout the city to measure heavy settleable dust, showed no significant change from previous years and remained well above objectives in the industrial and central area of the city.

The network of fluoride monitors indicated similar concentrations to 1985. A new fluoride sampler near the City's lone brick plant showed that levels near this plant exceeded objectives by a large margin, sufficient to cause vegetation damage. A major study performed in the Toronto area showed that the levels do not pose a human health risk, however, Abatement staff are investigating the plant.

Gaseous pollutants showed little change. Ozone is one of two gases which continued to exceed criteria. It is a product of long range transport and is produced photochemically to excess during the summer. Highest levels were measured on the "mountain". The other problem pollutants are reduced sulphur compounds which cause odours, particularly during inversions. A new sampler located on the "mountain" indicated the odours can extend to the far ends of the City occasionally.

The Phytotoxicology Section's 1986 survey of silver maple foliage found light amounts of visual injury due to air pollution, but only at three locations close to the industrial complex.

The Air Resources Branch conducted a mobile van survey in the fall of 1986 and found Stelco to be a significant source of nitrogen oxides, and Domtar to be a significant source of napthalene and total reduced sulphur compounds sufficient to exceed ambient air quality standards and guidelines. Dofasco and Columbian Chemicals met all standards and guidelines during the survey.

Total reduced sulphur compounds are a major cause of odours. Negotiations with industry for reductions of these emissions have been completed. Trial control programs are underway at Stelco, Domtar and Dofasco. Napthalene is also an odourous compound and Domtar's control programs will eliminate these odours.

2. INTRODUCTION

The Air Management Program in Ontario is based on controlling man- made emissions to meet ambient air quality objectives, which in turn are based on known effects on health, quality of life or sensitive vegetation, whichever is most stringent. To achieve these objectives, sources of pollution are identified, their emissions evaluated and appropriate control measures are instituted. Ambient air monitoring is used to identify pollution sources and to verify that the controls have been successful. Monitors are mainly sited in areas suspected of experiencing higher levels of air pollution. When these areas achieve acceptable air quality, then it is assumed that other areas should also be acceptable.

3. MONITORINC NETWORK

The Ministry of the Environment operates a network of ambient air monitors throughout Hamilton as shown in Figure 1 and Table 1. Monitoring is concentrated in the lower city, i.e., the area below the Niagara Escarpment, where for many years the network was centered on two major stations which monitored a variety of pollutants with automated analyzers.

The main station, known as 29025 (Barton/Sanford) provides the data which formed the basis for the Hamilton Air Pollution Index (API). The other major station is known as 29102 (Beach Blvd.)

In 1985, three new major air monitoring stations were established in the City in preparation for the new Air Quality Index. An east end station 29105 was established at Nash Road and Kentley Drive; a west end station 29118 was located on Main Street West at the Highway 403 cutoff, and a mountain station 29114 was sited on Vickers Road at East 18th Street. These stations each contain several continuous analyzers and particulate samplers, giving broad automated coverage of the City.

The remainder of the network consists of numerous but less sophisticated monitors, most of which have been in existence since at least 1970. In addition to this regular network, special surveys are carried out to identify specific problems. Two special surveys were conducted by the Ministry's Air Resources Branch in 1986, the results of which are presented in this report. These surveys were the Phytotoxicology Section's annual survey of vegetation studies done in August 1986, and the Air Quality and Meteorology Section's three week survey with two mobile air monitoring vans in October 1986.

Meteorological data (wind speed, wind direction and air temperature) are observed at station 29026, (Woodward Avenue) located on the sewage treatment plant grounds. Figure 2 presents the wind frequency distribution measured and clearly indicates the predominant west and southwest winds which occur in the area.

The results of a computer program known as a "pollution rose" are included in this report. The program is essentially a cross-tabulation of hourly pollutant concentrations with wind direction classes. The data from this program are illustrated on various diagrams. For each "rose" presented, the length of each line drawn is proportional to the average concentration of a pollutant when the wind was blowing <u>from</u> that direction. The longest lines in the diagram usually point to a source or sources of the pollutant in question. The concentrations will be influenced both by the quantity of emissions and by meteorological conditions such as wind speed, etc. As a result, the program is a useful tool in identifying sources of pollutants.

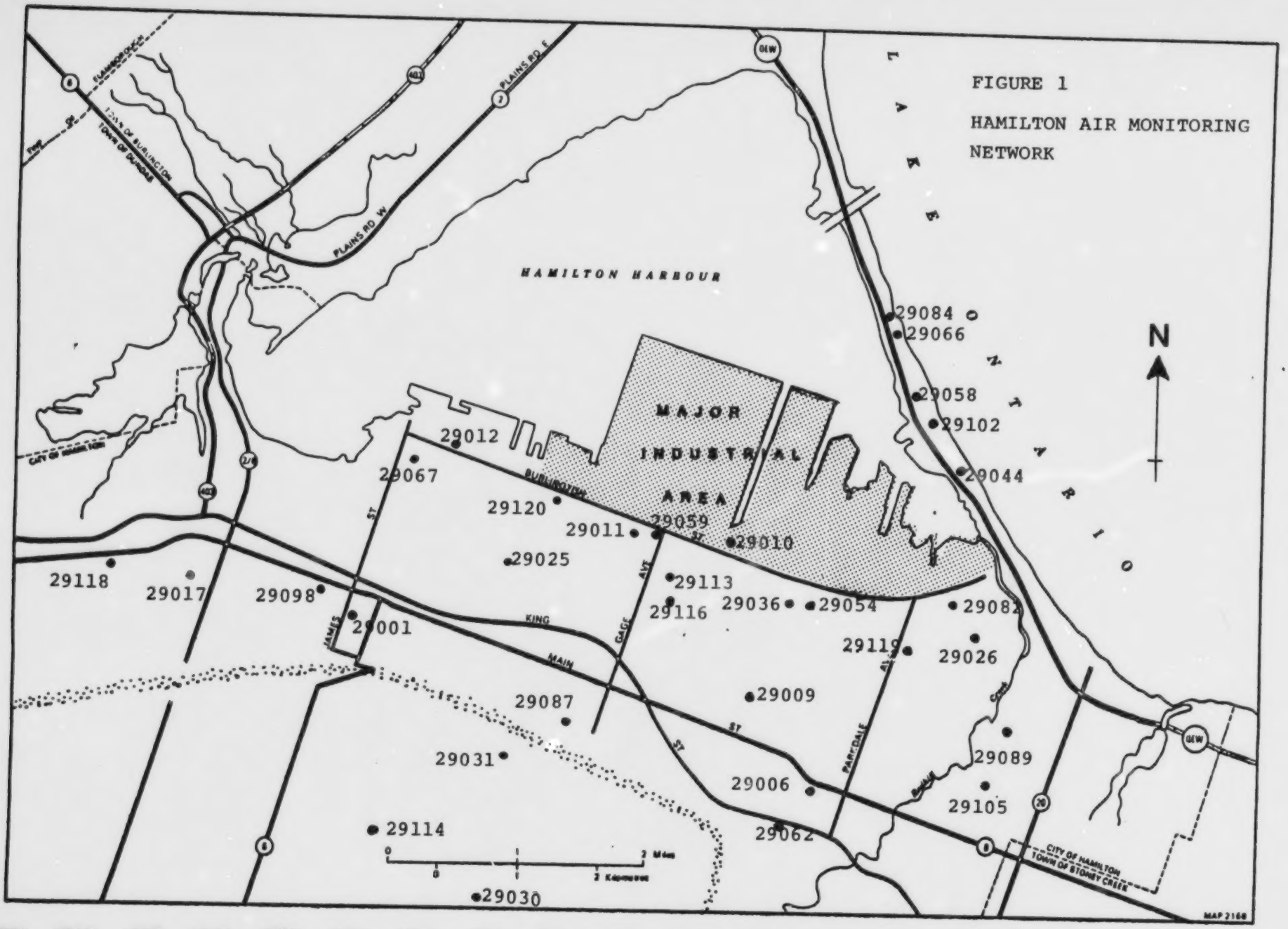


FIGURE 1
HAMILTON AIR MONITORING NETWORK
HAMILTON HARBOUR
LAKE ONTARIO
MAJOR INDUSTRIAL AREA
N
29084
29066
29058
29102
29044
29012
29067
29120
29011
29059
29010
29025
29118
29017
29098
29001
29113
29116
29036
29054
29082
29119
29026
29009
29087
29031
29006
29062
29089
29105
29114
29030
BURLINGTON ST
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
PLAINS RD W
PLAINS RD E
CITY OF HAMILTON
TOWN OF STONEY CREEK
MAP 2168

TABLE 1

HAMILTON AIR MONITORING STATION LOCATIONS

NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	SOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29001	Hughson/Hunter							X	X	X	X	
29006	Queenston/Craigroyston										X	
29009	Kenilworth/Roxborough								X		X	
29010	Burlington/Ottawa										X	
29011	Burlington/Leeds								X		X	
29012	Burlington/Wellington								X	X	X	
29017	Chatham/Frid								X		X	
29025	Barton/Sanford	X	X	X	X	X	X	X	X	X	X	
29026	Woodward/Brampton											X
29030	Camden/Mohawk										X	
29031	Concession/Up. Sherman										X	
29036	Roosevelt/Beach Road										X	
29044	Wark/Beach Blvd.										X	

TABLE 1 (cont.)

HAMILTON AIR MONITORING STATION LOCATIONS

NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	SOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29054	Beach Road/Conrad									X		
29058	QEW Arden									X		
29059	Burlington/Gage									X		
29062	King E./Barons									X		
29066	Killarney/Beach Blvd.									X		
29067	Hughson N./Macaulay								X			
29082	Leaside/Knox										X	
29084	Rembe/Beach Blvd.										X	
29087	Cumberland/Prospect								X			
29089	Barton/Nash								X			
29098	Bay/Main West								X			
29102	Beach Blvd./Towers		X		X	X	X	X	X		X	
29105	Nash/Kentley		X	X				X				

TABLE 1 (cont.)

HAMILTON AIR MONITORING STATION LOCATIONS

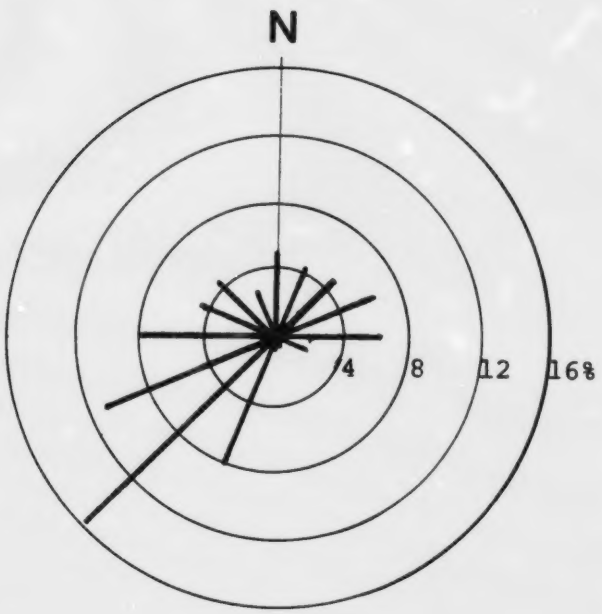
NUMBER	LOCATION	AIR POLLUTION INDEX	SULPHUR DIOXIDE	OZONE	CARBON MONOXIDE	OXIDES OF NITROGEN	TOTAL REDUCED SULPHUR	SOILING INDEX	SUSPENDED PARTICULATE	FLUORIDE	DUSTFALL	WIND/TEMP
29113	Gertrude/Depew								X			
29114	Vickers/East 18th		X	X			X	X				
29115	London/Justine									X		
29116	Dalkeith/Ottawa									X		
29118	Main W./Highway 403		X	X		X		X	X			
29119	Morley/Parkdale								X	X		
29120	Dickson/Burlington									X		

FIGURE 2

WIND FREQUENCY DISTRIBUTION

HAMILTON 1986

29026 - Woodward Ave. Sewage Treatment Plant



Lines indicate direction wind blew <u>from</u>

4. ANALYSIS OF DATA

4.1 Air Pollution Index

The Hamilton air pollution index (API) is used as a warning system to alert the public to elevated air pollution levels and as a trigger for cutbacks in industrial emissions. It is derived from 24 hour average concentrations of sulphur dioxide and particulate matter measured at the Barton/ Sanford station. The combination of these two pollutants at elevated levels is indicative detrimental human health effects. Hourly concentrations of both pollutants are telemetered to a central computer facility in Toronto which then calculates the index hourly, based on the following equation:

$$API = 2.5(13.9\ COH + 104.5\ SO_2).^8$$

Where: COH is the 24-hour average soiling index concentration expressed in coefficient of haze units.

SO_2 is the 24-hour average sulphur dioxide concentration expressed in parts per million.

No action is taken for readings up to 31. At 32, known as the advisory level, and with a forecast of unfavorable dispersion conditions, major industries are notified and asked to voluntarily curtail certain operations. At an API of 50, cutbacks by these sources become mandatory. These levels are set with a considerable safety margin before health effects to sensitive people would be expected. At 75, further cutbacks would be ordered and at 100, all sources not essential to public health and safety could be ordered to cease operations.

During 1986, there were five incidents in which the API reached or exceeded 32 three in the spring and two in the fall, as given in Table 2.

All five incidents were a result of the classical lake breeze phenomenon, in which a warm southerly air mass was undercut by a cool northeast breeze off a cold Lake Ontario.

A high variability in the numbers of incidents each year is shown in Table 2. This variability from year to year is weather related, that is, the frequency of typical inversion conditions.

The API station in Hamilton was located at the interface between the heavy industrial and residential areas of the city and about half-way between downtown and the major steel mills. It was directly downwind of the industrial area during times of poorest atmospheric dispersion.

TABLE 2

AIR POLLUTION INDEX - 1986

OCCASIONS WHEN 32 OR ABOVE

Date	No. of Hours ≥ 32	Maximum
1986		
1. April 27	4	32
2. May 14-15	18	37
3. June 10-11	15	34
4. November 7	4	32
5. November 23	7	32

NUMBER OF INCIDENTS AND HOURS ABOVE 31

	Number	Hours	Maximum
1986	5	48	37
1985	2	28	36
1984	9	153	44
1983	1	26	37
1982	13	203	39
1981	8	118	38
1980	5	71	40
1979	22	485	55
1978	7	93	43
1977	9	201	44

Hamilton's API levels are frequently compared to other areas in the Province. Such comparisons are not always valid since APIs in different cities are not strictly comparable. Hamilton's API station in particular, was more oriented to a large heavy industrial area than most of the other API stations in the Province.

It is important to note that the API station was also located close to a major street - Barton Street, and at ground level. A prime cause of elevated API values was the soiling index (co-efficient of haze) term in the API equation. Peaks at rush hour, particularly during inversions were prominent in the data, as were reduced levels during night hours when traffic was reduced.

In 1987, a new station was located closer to the downtown area and it now reports the Air Pollution Index. This station has been sited to be more remote from individual traffic influences and thus gives a more accurate representation of general downtown air quality in Hamilton.

4.2 Particulates

There are three basic types of instruments employed for the measurement of particles, each type relating to a different size range:

(a) Dustfall jars measure heavy material, generally greater than 10 microns in diameter (one micron is one-millionth of a metre).
(b) High volume samplers measure suspended particulates ranging in size from submicron to 50 microns and
(c) Co-efficient of haze tape samplers measure mostly fine material - from submicron to about 10 microns.

The ambient air quality objectives for suspended particulate are based on health effects when occurring in combination with sulphur dioxide. As mentioned previously, this combination was proven to be indicative but not necessarily causative of such health effects. The dustfall objectives are based on nuisance effects while the soiling index objectives were derived from correlations with suspended particulate data.

4.2.1 Total Suspended Particulates

A high volume sampler draws a known volume of air through a pre-weighed filter for a 24 hour period (midnight to midnight). The exposed filter is weighed and the difference (weight of particulate on filter) in conjunction with the known air flow is expressed as a concentration in micrograms per cubic meter. The objective for a 24-hour average is 120 ug/m^3 while the yearly geometric mean objective is 60 ug/m^3.

TABLE 3a

SUSPENDED PARTICULATES - 1986
UNIT - MICROGRAMS PER CUBIC METER
unless otherwise specified

ONTARIO OBJECTIVES: 24 hour - 120
1-year Geo. Mean - 60

LOCATION	Geometric Mean 1984	1985	1986	Maximum 1986	%of Samples Above 120 1986
29001 - Hughson/Hunter	75	55	70	468	16
29009 - Kenilworth/Roxborough	63	56	61	193	7
29011 - Burlington/Leeds	102	113	110	341	37
29012 - Burlington/Wellington	80	83	66	212	12
29017 - Chatham/Frid	87	61	79	201	18
29025 - Barton/Sanford	81	71	75	337	16
29067 - 450 Hughson St. N.	58	52	51	137	3
29087 - Cumberland/Prospect	59	56	52	243	5
29089 - Barton/Nash	57	55	62	142	2
29098 - Bay/Main	55	42	52	287	11
29102 - Beach Blvd.	-	69	73	229	20
29113 - Gertrude/Depew	-	-	87^{9}	321	21
29114 - Vickers/East 18th	53	41	45*	139	4
29118 - Main W./Highway 403	65	47	47+	193	5
29119 - Morley/Parkdale	-	-	96^{11}	206	33

9 - Numerical exponent refers to number of months sampled when less than 12.
* - Station moved to 29114 from 29085 in mid-1985
+ - Station moved to 29118 from 29090 at end of 1985

At two locations in Hamilton, these samplers operate daily. At eleven other locations, they run on a once every sixth day cycle, consistent with the practice in other North American jurisdictions.

Suspended particulate data is summarized in Table 3a and shows a definite gradient of higher concentrations closer to the industrial area. With certain exceptions, concentrations in 1986 were fairly similar to 1985 levels.

Some stations did show large increases such as 29001 (Hughson/Hunter) and 29098 (Bay/Main) downtown and 29017 (Chatham/Frid) in the west end. These three stations had recorded much lower than normal means in 1985. Other stations increased only marginally. These trends may have been due to an increased importation of long range transported pollutants. This was evidenced by an increase in sulphate concentrations, not only in Hamilton but throughout southern Ontario.

Station 29012 (Burlington/Wellington) decreased substantially from 1984-85 levels. This was likely due to the completion of construction activities in the vicinity.

Two new stations were located in the industrial area at 29113 (Gertrude/Depew) and 29119 (Morley/Parkdale). Both recorded elevated levels well above the yearly objective.

The overall trend in TSP since 1970 is shown in Figure 3, which displays a leveling off in concentrations since 1977. The trend curve for industrial emissions shows a slight downward trend over this period. It is possible that the TSP curve does not follow because several stations were unduly influenced by localized emissions such as road traffic.

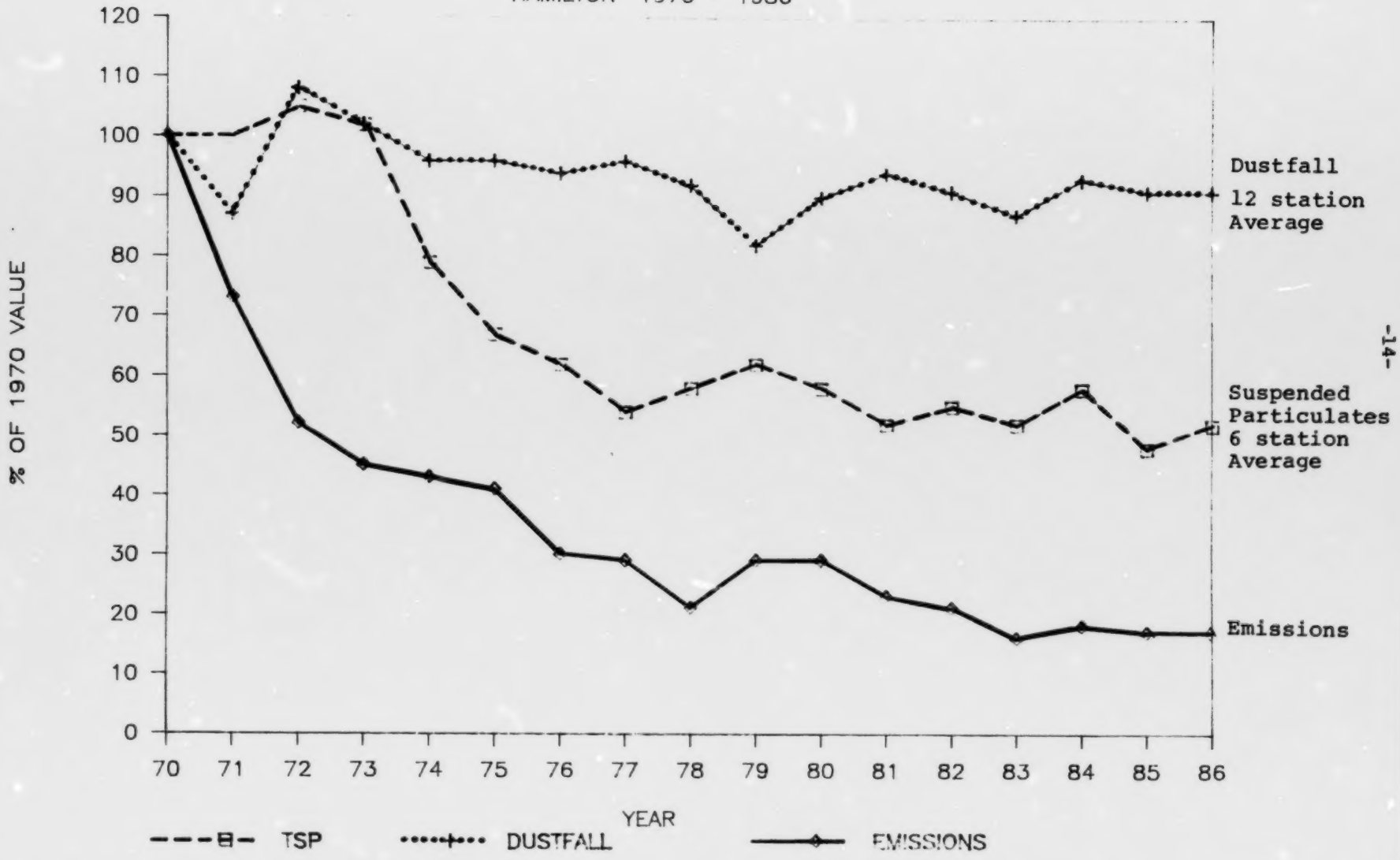
Pollution roses (Figures 4-6) for 1981-86 suspended particulates were manually calculated for all stations by grouping the data according to predominant daily wind directions (as opposed to the hourly pollution rose computer program which classes hourly data). Only those days for which a clear predominant direction could be determined were included and rainfall/snowfall days were excluded. Since most of the stations operate once every sixth day, roses for a single year cannot be drawn due to an insufficient number of samples per year. A multi-year approach was made therefore. Most of the 14 roses indicate a strong correlationship of higher averages with winds from the industrial sector. Several of the roses indicate local non-industrial influences as well, such as road traffic.

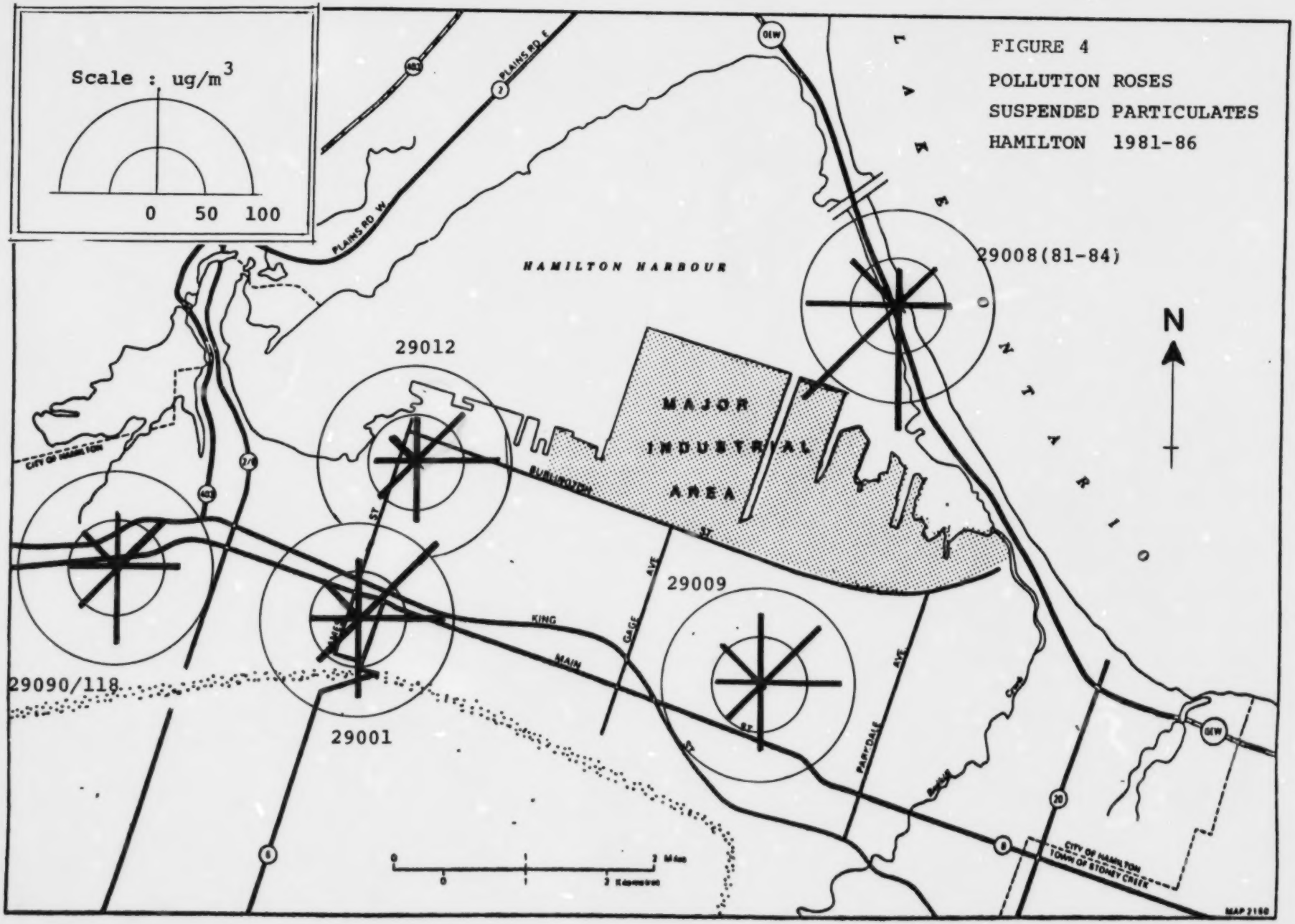
The hi-vol filters were analyzed for seven metals, as well as sulphates and nitrates (Table 3b).

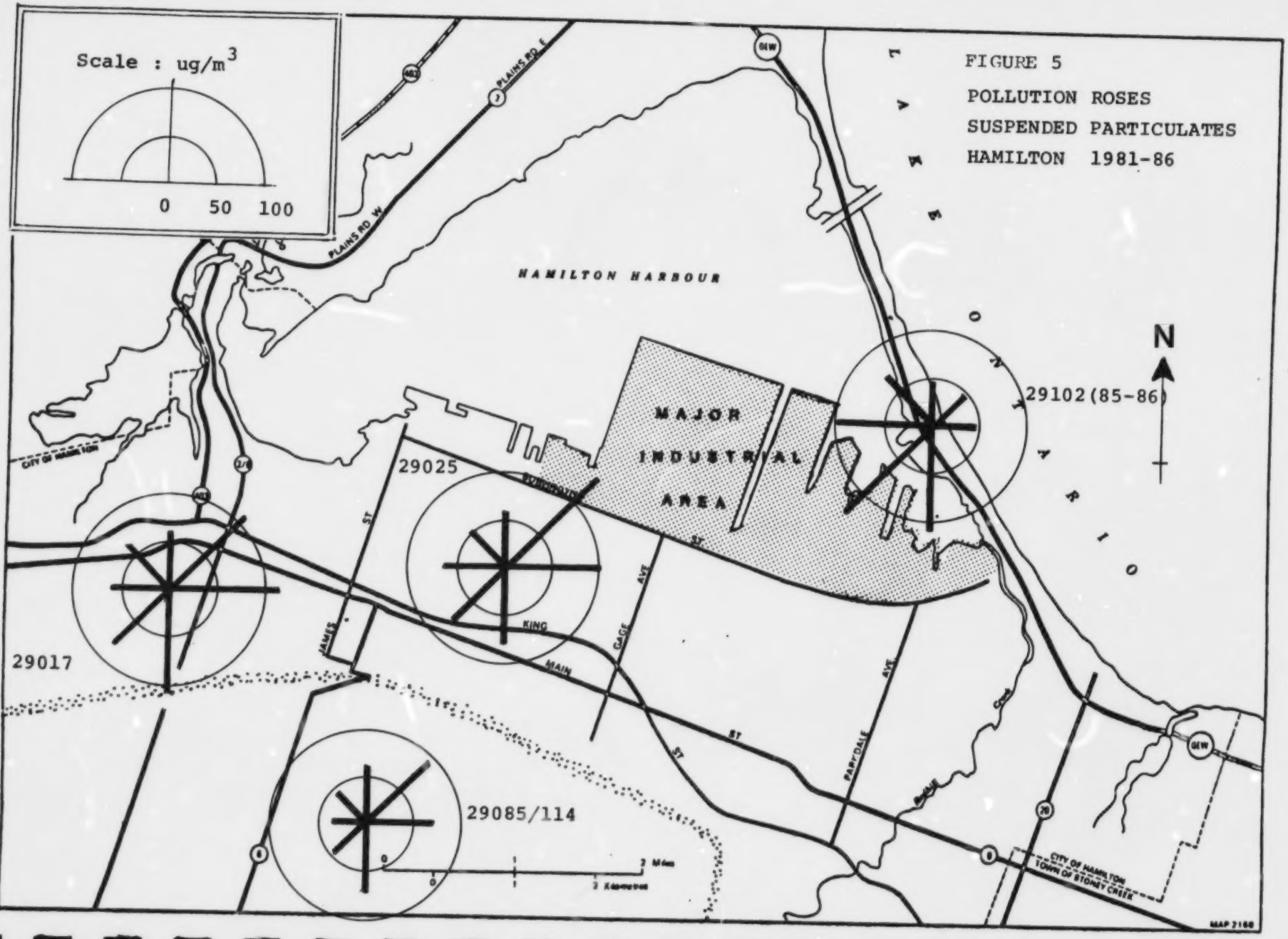
FIGURE 3

PARTICULATE / EMISSIONS TRENDS

HAMILTON 1970 – 1986




Scale : ug/m3
0 50 100
FIGURE 4
POLLUTION ROSES
SUSPENDED PARTICULATES
HAMILTON 1981-86
HAMILTON HARBOUR
LAKE ONTARIO
29008(81-84)
29012
29009
29090/118
29001
MAJOR INDUSTRIAL AREA
N
PLAINS RD E
PLAINS RD W
BURLINGTON ST
KING ST
MAIN ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK


Scale : ug/m3
0 50 100
FIGURE 5
POLLUTION ROSES
SUSPENDED PARTICULATES
HAMILTON 1981-86
HAMILTON HARBOUR
MAJOR INDUSTRIAL AREA
29102 (85-86)
29025
29017
29085/114
N
PLAINS RD W
PLAINS RD E
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK

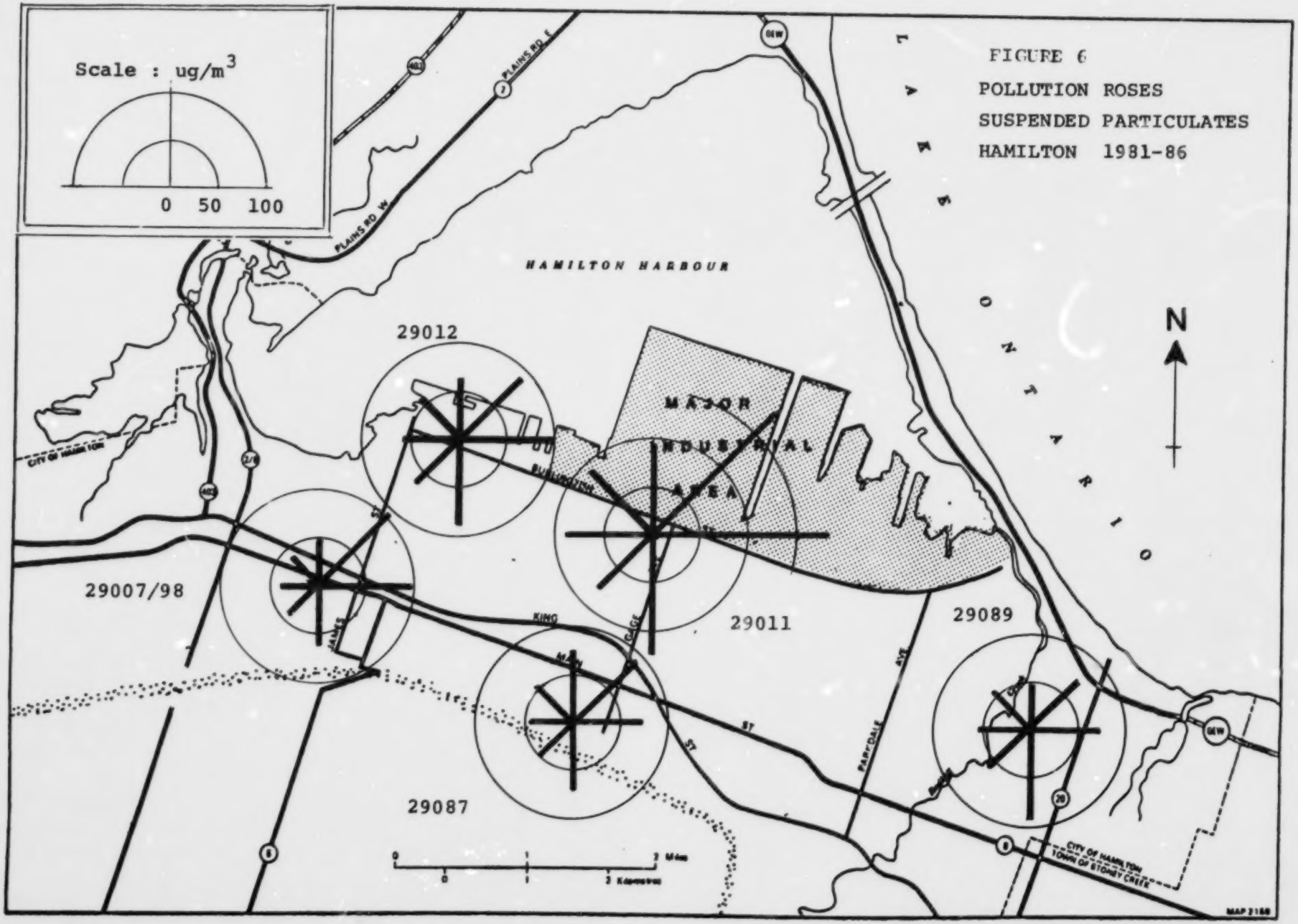


FIGURE 6
POLLUTION ROSES
SUSPENDED PARTICULATES
HAMILTON 1981-86

Concentrations of nickel, cadmium, lead and vanadium showed very low concentrations which did not vary appreciably throughout the city indicating that these were background levels. The 24 hour criteria for these metals were easily met.

Concentrations of chromium and manganese showed a gradient with distance from the industrial area. However, even the highest levels were well below acceptable levels.

Iron concentrations were high, and also showed a gradient with distance from the industrial area where concentrations were often well above general background levels, but usually below guideline values which are based mainly on soiling effects.

The sulphate/nitrate components comprised a large portion of the measured particulate matter. These constituents are largely by-products of major high temperature fuel combustion sources and can travel hundreds of miles from their source. The concentrations in Hamilton were generally higher in the industrial area, indicating a contribution from local industries. Elevated concentrations at most of the stations during northeast winds, confirm this. However, it should be remembered that northeast winds are often associated with inversion conditions. This results in poor dispersion, aggravating the build-ups of pollutants from all sources. Most of the City shows levels only moderately higher than other areas in the province including rural areas, indicating that much of this material is imported into the city via long range transport from distant sources. The sulphate/nitrate components are known to be a factor in reduced visibility[2] and are often likely responsible for the widespread haze observed in Hamilton during southerly winds.

The sulphate concentrations showed large increases at most stations in 1986 returning to pre-1985 levels. The nitrate portion was unchanged in most cases. The increase in sulphate levels which are largely imported into the city, may indicate that a greater amount of "background" particulate entered the city from distant sources. As mentioned previously, sulphate levels increased throughout Southern Ontario in 1986.

TABLE 3b CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

Station and Year	CADMIUM # of Samples	CADMIUM Geo. Mean	CADMIUM Max.	CHROMIUM # of Samples	CHROMIUM Geo. Mean	CHROMIUM Max.	IRON # of Samples	IRON Geo. Mean	IRON Max.	LEAD # of Samples	LEAD Geo. Mean	LEAD Max.	MANGANESE # of Samples	MANGANESE Geo. Mean	MANGANESE Max.
	Criterion: 2.0(24 Hours)									Criterion: 5.0(24 Hours)					
29001 Hughson/Hunter															
1983	55	.001	.028	55	.004	.039	55	1.4	13.2	55	0.3	1.4	55	.06	.70
1984	57	.002	.006	57	.001	.060	57	1.9	11.4	57	0.4	1.1	57	.10	.83
1985	57	.001	.004	57	.001	.073	57	1.5	11.1	57	0.2	0.5	57	.09	.57
1986	59	.000	.017	59	.001	.084	59	1.7	38.0	59	0.2	1.1	59	.10	2.39
29008/29102 Beach Blvd.															
1983	337	.001	.006	337	.004	.045	337	2.4	15.4	330	0.4	2.4	337	.15	.98
1984	51	.001	.005	51	.007	.056	51	3.1	13.9	51	0.4	1.2	51	.21	.92
1985*	52	.001	.004	52	.002	.037	52	2.5	12.2	52	0.1	0.5	52	.18	.81
1986	57	.001	.006	57	.002	.033	57	3.0	10.0	57	0.2	0.6	57	.17	.87
29011 Burlington/Leeds															
1983	54	.001	.004	54	.013	.056	54	4.5	19.3	54	0.3	1.0	54	.28	.98
1984	59	.002	.015	59	.013	.219	59	5.1	18.3	59	0.4	0.9	59	.34	1.48
1985	58	.002	.005	58	.020	.092	58	5.7	23.2	58	0.3	0.7	58	.40	2.16
1986	59	.001	.004	60	.018	.067	60	4.9	24.9	60	0.2	0.7	60	.40	1.32
29012 Burlington/ Wellington															
1983	52	.001	.005	52	.003	.028	52	1.6	9.9	52	0.2	1.2	52	.10	.61
1984	57	.001	.010	57	.002	.038	57	1.9	10.2	57	0.3	0.8	57	.11	.43
1985	58	.001	.022	58	.002	.052	58	2.1	6.0	58	0.2	0.5	58	.16	1.29
1986	59	.000	.003	59	.001	.023	59	1.2	10.8	59	0.1	0.5	59	.13	.91

*29008 moved to 29102 in 1985.

TABLE 3b CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

Station and Year	NICKEL Criterion: 2.0(24 Hours) # of Samples	Geo. Mean	Max.	VANADIUM Criterion: 2.0 (24 Hours) # of Samples	Geo. Mean	Max.	NITRATE # of Samples	Geo. Mean	Max.	SULPHATE # of Samples	Geo. Mean	Max.
29001 Hughson/Hunter												
1983	55	.002	.030	55	.00	.03	55	3.4	19.7	55	9.3	48.3
1984	57	.005	.049	57	.00	.04	57	4.2	16.6	57	10.7	35.8
1985	57	.002	.015	57	.00	.04	57	3.1	10.0	57	6.9	16.2
1986	59	.001	.028	59	.00	.04	59	4.4	37.2	59	10.6	29.7
29008/29102 Beach Blvd.												
1983	315	.002	.112	337	.00	.07	337	3.5	23.0	337	11.0	49.0
1984	51	.004	.043	51	.00	.04	50	4.2	27.2	50	11.6	35.1
1985*	52	.003	.022	52	.00	.03	37	2.8	16.6	37	8.4	19.4
1986	57	.000	.025	57	.00	.04	57	3.5	18.8	57	10.9	39.7
29011 Burlington/Leeds												
1983	48	.004	.018	54	.01	.02	54	3.3	17.2	54	10.9	26.3
1984	59	.006	.024	59	.01	.04	58	3.6	19.6	58	11.7	33.8
1985	58	.004	.026	58	.00	.05	58	4.1	19.3	58	10.7	26.0
1986	60	.001	.024	60	.01	.04	60	4.0	36.4	60	12.3	43.4
29012 Burlington/ Wellington												
1983	46	.003	.024	52	.00	.02	52	3.8	21.1	52	10.0	19.8
1984	57	.003	.149	57	.00	.05	57	4.1	18.0	57	9.6	36.4
1985	58	.002	.059	58	.00	.03	57	4.3	14.9	57	9.2	21.7
1986	59	.000	.017	59	.00	.06	59	4.0	34.9	59	9.4	40.0

*29008 moved to 29102 in 1985.

TABLE 3b CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

Station and Year	CADMIUM Criterion: 2.0(24 Hours) # of Samples	CADMIUM Geo. Mean	CADMIUM Max.	CHROMIUM # of Samples	CHROMIUM Geo. Mean	CHROMIUM Max.	IRON Criterion: 5.0(24 Hours) # of Samples	IRON Geo. Mean	IRON Max.	LEAD # of Samples	LEAD Geo. Mean	LEAD Max.	MANGANESE # of Samples	MANGANESE Geo. Mean	MANGANESE Max.
29017 Chatham/Frid															
1983	56	.001	.004	56	.004	.027	56	2.0	8.4	57	0.2	1.8	56	.10	.43
1984	57	.001	.003	57	.003	.033	57	2.2	9.1	57	0.3	1.9	57	.11	.77
1985	57	.001	.003	57	.001	.036	57	1.7	6.2	57	0.2	0.4	57	.09	.49
1986	57	.000	.002	57	.004	.035	57	2.3	12.8	57	0.2	0.7	57	.11	.47
29025 Barton/Sanford															
1983	328	.001	.020	327	.005	.100	328	2.2	15.3	328	0.3	2.5	328	.13	1.49
1984	57	.002	.011	57	.004	.073	57	3.1	22.5	57	0.4	2.2	57	.18	1.42
1985	51	.001	.006	51	.004	.309	51	1.5	14.9	51	0.3	1.1	51	.19	1.74
1986	55	.001	.004	55	.002	.086	55	2.7	26.8	55	0.3	1.0	55	.15	1.19
29067 Hughson/Macauley															
1983	56	.001	.003	56	.002	.022	56	0.9	5.4	56	0.2	0.5	56	.05	.36
1984	56	.001	.005	56	.002	.027	56	1.3	9.9	56	0.2	0.6	56	.07	.59
1985	58	.001	.009	58	.001	.026	58	1.4	5.4	58	0.1	0.4	58	.09	.43
1986	58	.001	.003	58	.003	.028	58	1.0	11.6	58	0.1	0.5	58	.07	.50
29085/29114 Vickers/East 18th															
1983	57	.001	.007	57	.001	.035	57	1.1	13.5	57	0.2	1.2	57	.06	.60
1984	58	.001	.007	58	.001	.034	58	1.1	9.5	58	0.2	0.8	58	.06	.69
1985	57	.001	.003	57	.001	.084	57	0.8	9.7	57	0.1	0.5	57	.06	.39
1986*	54	.001	.005	54	.001	.026	54	0.7	8.7	54	0.1	0.6	54	.05	.44

*29085 moved to 29114 at end of 1985

TABLE 3b CONSTITUENTS IN SUSPENDED PARTICULATE (ug/m^3)

Criterion: 2.0(24 Hours) Criterion: 2.0(24 Hours)

Station and Year	NICKEL # of Samples	NICKEL Geo. Mean	NICKEL Max.	VANADIUM # of Samples	VANADIUM Geo. Mean	VANADIUM Max.	NITRATE # of Samples	NITRATE Geo. Mean	NITRATE Max.	SULPHATE # of Samples	SULPHATE Geo. Mean	SULPHATE Max.
29017 Chatham/Frid												
1983	47	.006	.037	56	.00	.05	56	3.8	18.5	56	10.0	24.2
1984	57	.007	.066	57	.00	.03	58	4.0	18.1	58	11.0	24.7
1985	57	.004	.021	57	.00	.03	58	3.2	11.2	58	6.6	17.6
1986	57	.001	.022	57	.00	.14	57	3.5	11.5	57	9.3	44.0
29025 Barton/Sanford												
1983	328	.004	.041	328	.00	.04	328	3.7	21.6	328	10.1	31.8
1984	57	.005	.028	57	.00	.03	57	3.4	16.4	57	10.4	35.1
1985	51	.006	.040	51	.00	.04	52	3.3	14.7	52	8.4	18.9
1986	55	.001	.042	55	.00	.05	57	4.0	33.5	57	11.3	25.1
29067 Hughson/Macauley												
1983	56	.002	.015	54	.00	.03						
1984	56	.005	.031	56	.00	.02						
1985	58	.004	.039	58	.00	.03						
1986	58	.002	.020	58	.00	.02						
29085/29114 Vickers/East 18th												
1983	57	.001	.013	56	.00	.05	57	2.8	15.1	57	8.5	24.9
1984	58	.001	.030	58	.00	.03	58	3.2	14.3	58	8.4	28.5
1985	57	.001	.018	57	.00	.03	57	2.6	8.7	57	6.0	19.3
1986*	54	.003	.047	54	.00	.02	54	2.7	15.2	54	8.0	37.4
29087 Cumerland/Prospect												
1983							57	2.9	16.2	57	8.8	20.8
1984							55	3.0	15.8	55	8.8	26.8
1985							56	3.0	11.3	56	7.3	20.4
1986							58	3.4	42.4	58	9.2	38.9

*29085 moved to 29114 at end of 1985

It should be noted that the sulphate/nitrate analyses are subject to some error due to the measurement methodology and for this reason the data presented should be primarily used for evaluation of trends rather than use of the actual values. Alternative methodologies and filters are under investigation to improve the measurement technique. Preliminary tests with a new filter medium indicate that the glass fibre filter can cause as much as 8 ug/m^3 on average of spurious sulphate/nitrate formation from gaseous sulphur dioxide and nitrogen oxides. It is possible that the higher industrial area sulphate levels are related to this error, since gaseous sulphur dioxide levels are somewhat higher there.

Four stations' hi-vol filters were analyzed for total carbon, elemental carbon and carbonate. Elemental carbon would include material such as coal, coke and kish, while total carbon would include numerous forms, both organic and inorganic in nature. Carbonate would include calcium carbonate (limestone) and dolomite. Sources of these carbonaceous materials would include coke ovens, blast furnaces, stockpiles, vehicle exhaust, biological materials and crushed stone.

Data is given in Table 3c and shows a distinct gradient in concentrations with distance from the industrial area. Levels were highest at 29011 (Burlington/Leeds) in the middle of the industries, followed by 29025 (Barton/Sanford) and 29102 (Beach Blvd.) on the fringes of the area followed by much lower levels at 29114 (Vickers/E18th) on the mountain. These higher particulate levels are a result of both direct emissions and contributions from traffic, particularly heavy truck traffic.

A contour map of suspended particulate concentrations is given in Figure 7. It can be seen that the majority of the city met the yearly objective of 60 ug/m^3. Concentrations were mainly only elevated close to the industrial area. Once again it should be stressed that airborne particulate is not solely due to direct emissions from industrial sources. Dirty roadways and heavy truck traffic can also be contributors.

It should be realized also that these contour maps of concentrations are not a strictly definitive representation of city wide air quality. Local influences affect some of the stations and several more stations were required to fill in some gaps that were not covered. Four more hi-vol sampling stations have been installed in 1987. Two small contours drawn in Figure 7 have no scientific validity. They are only drawn to indicate that particular stations were subject to local sources such as traffic, unrepresentative of overall patterns.

TABLE 3c

CARBON CONTENTS IN SUSPENDED PARTICULATES (ug/m^3) - 1985-86

Station	Year	No. of Samples	TOTAL CARBON Geo. Mean	TOTAL CARBON Max.	ELEMENTAL CARBON Geo. Mean	ELEMENTAL CARBON Max.	CARBONATE (CO_3) Geo. Mean	CARBONATE (CO_3) Max.
29011 Burlington/Leeds	1985	58	13.7	35.2	5.0	18.1	1.3	11.3
	1986	55	11.5	45.6	3.8	18.0	1.2	10.5
29025 Barton/Sanford	1985	51	9.1	20.1	3.4	11.9	0.6	3.7
	1986	53	10.2	29.9	3.4	16.3	0.7	3.5
29085/114 Mountain	1985	55	5.9	18.9	1.8	8.9	0.4	2.5
	1986	52	5.4	23.4	1.0	6.8	0.1	2.7
29102 Beach Blvd.	1985	52	9.4	27.5	3.4	14.0	0.4	2.2
	1986	49	8.5	20.6	3.5	13.5	0.3	9.4

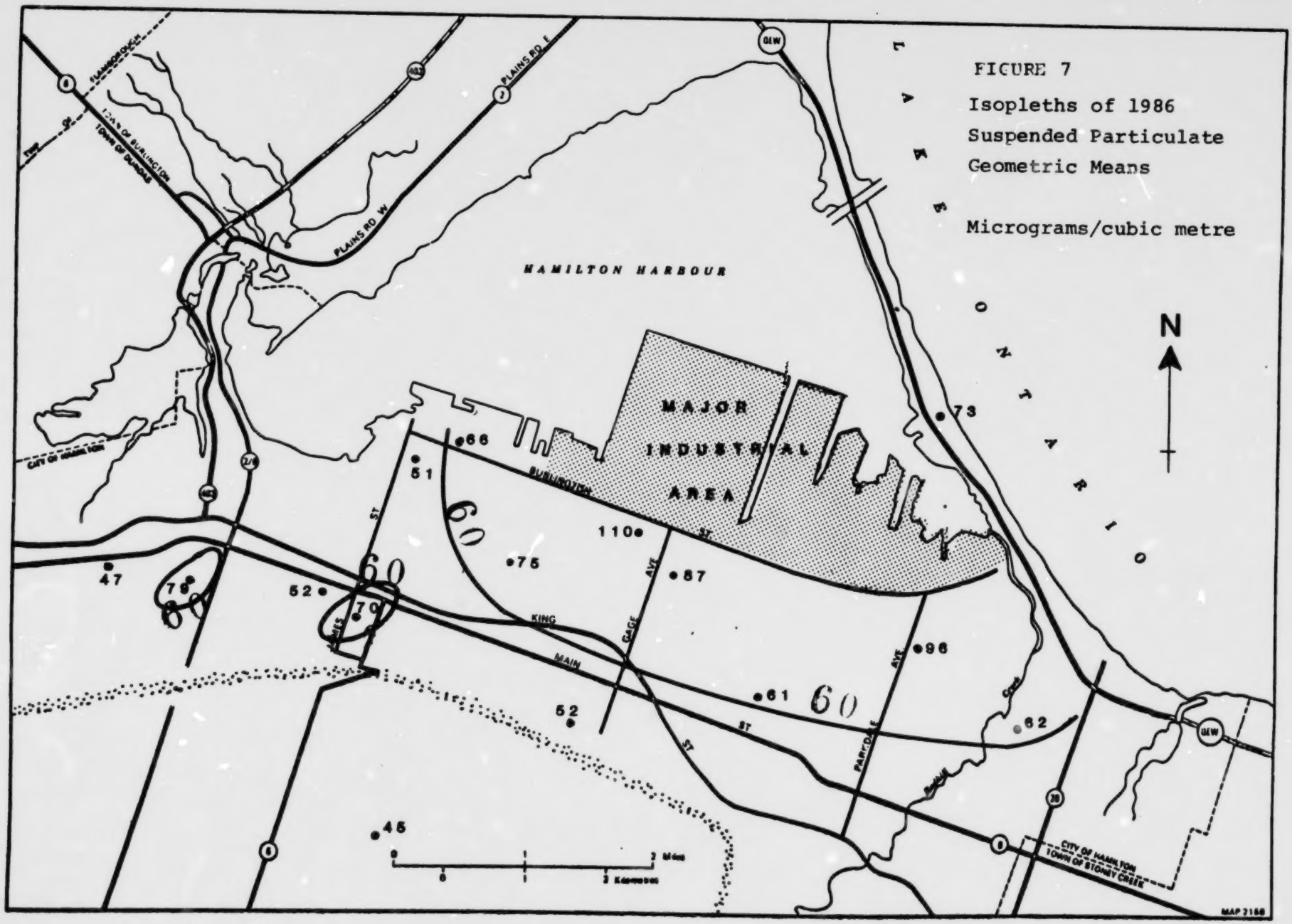


FIGURE 7
Isopleths of 1986
Suspended Particulate
Geometric Means
Micrograms/cubic metre
HAMILTON HARBOUR
MAJOR
INDUSTRIAL
AREA
LAKE ONTARIO
N
PLAINS RD W
PLAINS RD E
BURLINGTON ST
KING ST
MAIN ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF BURLINGTON
CITY OF HAMILTON
TOWN OF STONEY CREEK
66
51
73
110
75
87
47
78
52
79
96
61
62
52
45
60

Although the contour map in Figure 7 indicates a rather limited industrial contribution to suspended particulate levels throughout the city, it should be stressed that these maps reflect long term average conditions. Short term levels, particularly during inversions, accompanied by light northeast winds, indicate a different situation. Figures 8 and 9 depict suspended particulate contour maps during two elevated API incidents during the year. Each map readily displays increased concentrations measured city-wide, diminishing with distance from the industrial complex. The contours are also skewed toward the southwest reflecting the wind flow from the northeast. The industrial contribution is obvious on these occasions whether it be direct emissions, fugitive emissions or roadway sources inside or outside plants in the industrial area. Under inversion conditions, with poor dispersion, pollution from all sources including traffic can accumulate and will contribute to the totals.

This traffic effect is best illustrated in Figure 9 in the downtown area where a separate contour is drawn. Station 29001 (Hughson/Hunter) was extremely high at 468 ug/m^3, while a short distance away at 29098 (Bay/Main) the level was 287 ug/m^3. What is important to note is that 29098 is 75 ft above ground while 29001 is only 20 ft above. The latter's proximity to heavy downtown traffic probably accounts for this large difference in concentrations.

In conclusion, the suspended particulate data indicate that the industrial area has an impact on the City,but that the effect is usually limited to a relatively small area near the mill sites. During inversion conditions, broader impacts are noted.

Most major sources in industry have now been controlled and the remaining sources are being abated in compliance with Control Orders. These Orders include controls on cast houses for blast furnaces D and E and the No. 1 galvanizing line at Stelco and the No. 2 coke plant pushing emission controls at Dofasco. Dofasco is pursuing an agreed control program at the No. 1 melt shop. Stelco is experimenting with efficiency improvements to the particulate scrubber at the sinter plant. Improved controls have been installed on the SWARU incinerator. Inside company properties, programs are in operation to control roadway sources of particulate. Roads have been paved and road cleaning is performed regularly. Better control of trackout to public streets still appears necessary, however, as does improved cleaning of public streets. Landscaping of industrial properties has also been ongoing for some time in order to reduce wind-blown dust.

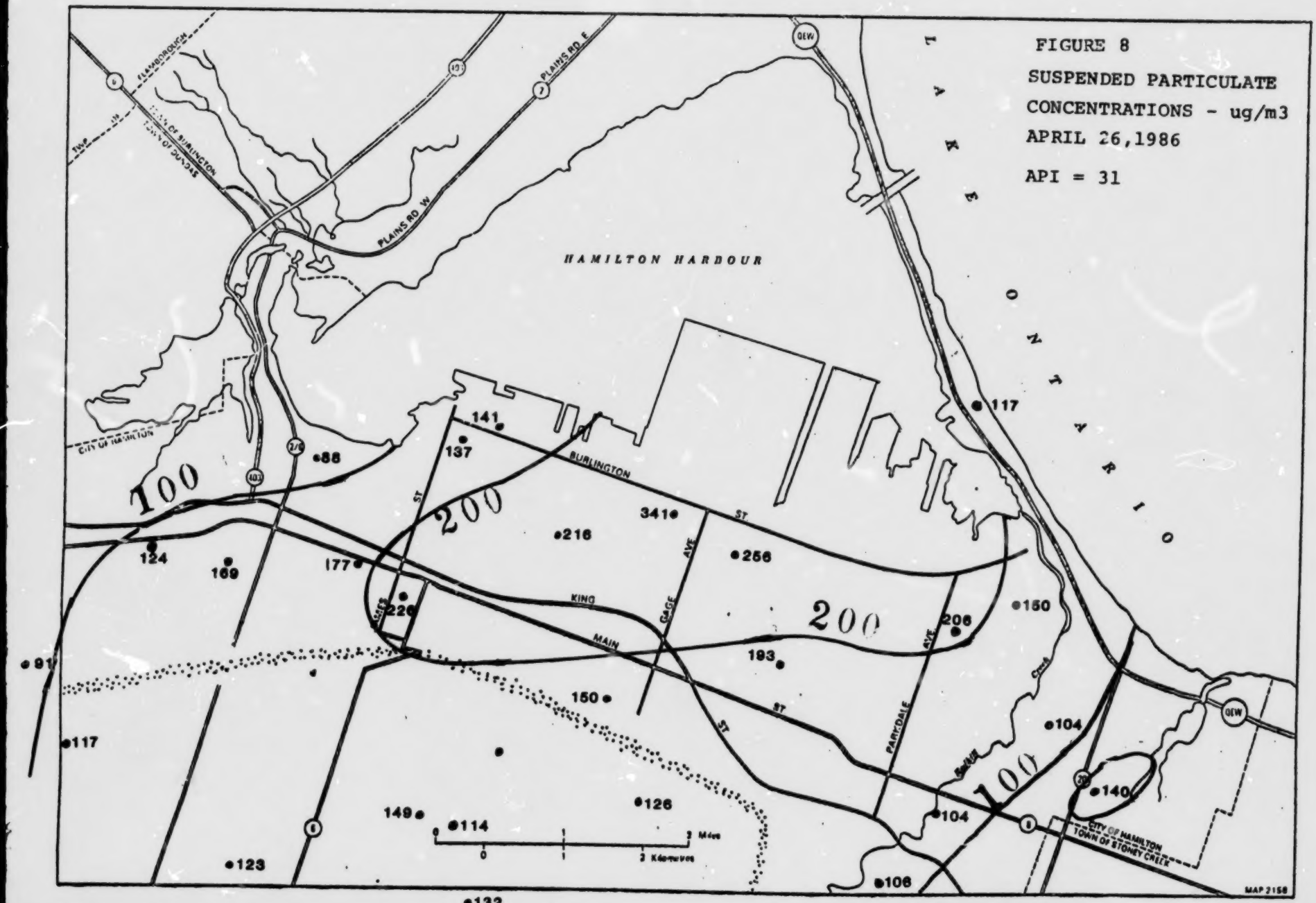


FIGURE 8
SUSPENDED PARTICULATE
CONCENTRATIONS - ug/m3
APRIL 26,1986
API = 31
HAMILTON HARDOUR
LAKE ONTARIO
PLAINS RD E
PLAINS RD W
BURLINGTON ST
KING ST
MAIN ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK
100
200
200
100
141
137
88
341
216
256
124
169
177
220
206
150
193
91
150
117
104
126
149
114
140
104
123
106
132
117
3 Miles
0
3 Kilometres
MAP 2158

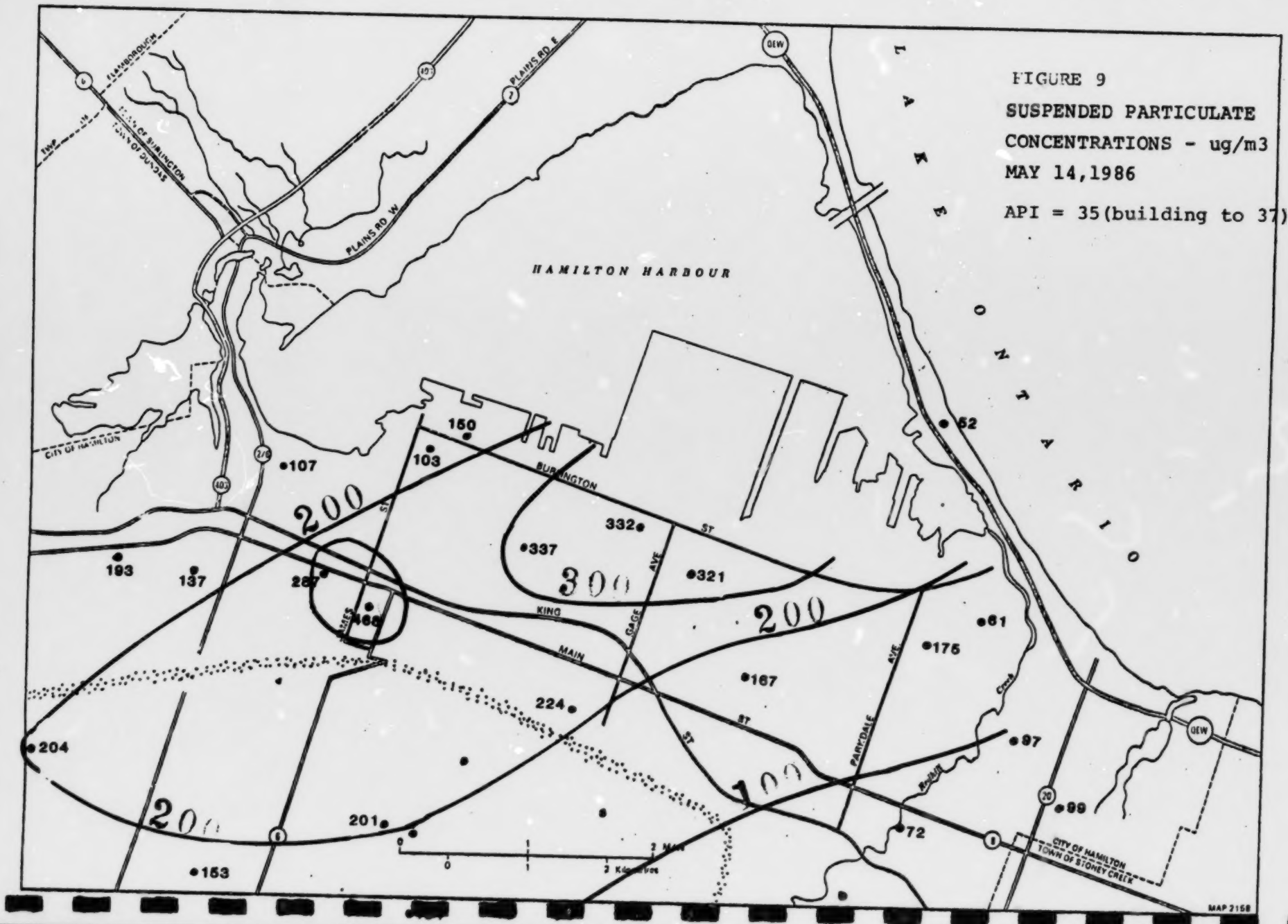


FIGURE 9

SUSPENDED PARTICULATE CONCENTRATIONS - ug/m3

MAY 14,1986

API = 35(building to 37)

4.2.2 Soiling Index (Co-efficient of Haze)

Co-efficient of haze tape samplers operate continuously and determine hourly soiling values. Air is drawn through a filter paper, and the optical density of the soiled spot is measured by light transmittance. The instrument has readings taken prior to and after sample collection. The resultant light obstruction is determined and transmitted on a real time basis to the data bank for the two main telemetered stations while manual reading of charts is still required for three newly installed monitors. Data are given in Table 4 for seven stations.

In 1986, concentrations were below the yearly objective at 29102 (Beach Blvd.), 29105 (Nash/Kentley), 29114 (Vickers/East 18th) and 29118 (Main West).Averages at 29001 (Hughson/Hunter) and 29025 (Barton/Sanford) were at and slightly above the objective respectively.

The daily objective was most frequently exceeded at Barton/Sanford - a total of 27 days.

Historical data are available only for the Beach and Barton stations and trend graphs for both are illustrated in Figure 10. Barton has fluctuated near the annual objective since 1972 while Beach dropped dramatically in 1985 and 1986. This drop coincided with the move of the Beach station from its old North Park location immediately adjacent to the Queen Elizabeth Way. This old location was obviously heavily impacted on by highway traffic. In 1984, the daily COH objective was exceeded 79 times at North Park, compared to only one time at the new Beach Blvd. location in 1986. This tends to indicate that the soiling index measurement predominantly measures vehicle traffic particulate when located close to a traffic artery. This would account for the fact that Barton/Sanford COH levels have decreased only a small amount since the early 1970's compared to the large decreases in industrial particulate emissions noted in Figure 4.

TABLE 4

SOILING INDEX

1-HOUR TELEMETERED INSTRUMENTS

UNITS - COH's per 1000 linear ft. of air

Ontario Objectives - 24-hour - 1.0
1-year - 0.5

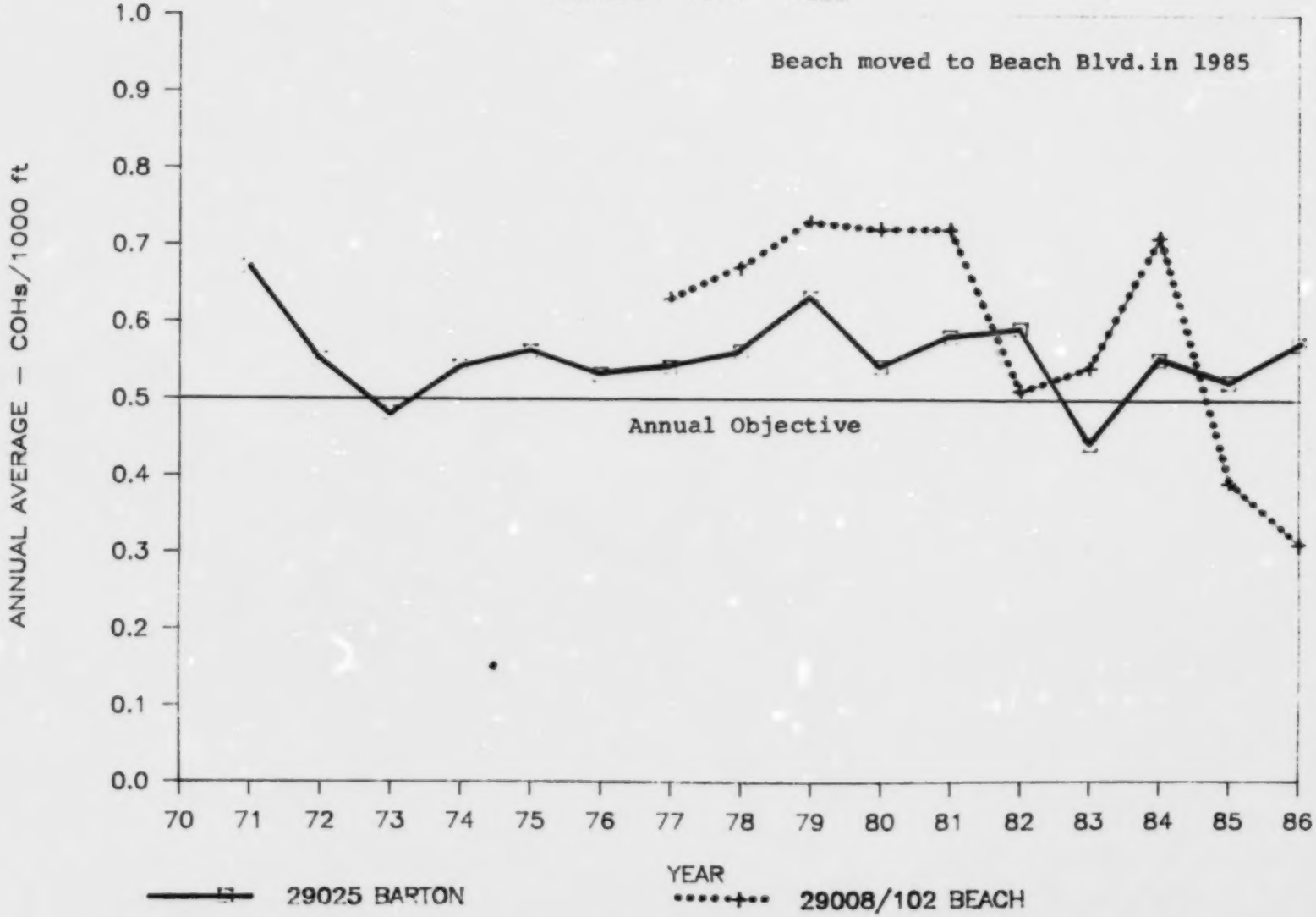
		Annual Average	Maximum 24-hour	No. of Times Above Objective 24-hour
29001 - Hughson/Hunter	1986	.50	1.7	10
	1985	.48	1.6	6
	1984	.60[9]	2.4	18
29008 - North Park 29102 Beach Blvd.	1986	.31	1.3	1
	1985	.39	1.2	3
	1984*	.71	1.7	79
	1983	.54	1.6	34
29025 - Barton/Sanford	1986	.57	1.6	27
	1985	.52	1.6	10
	1984	.55	2.4	25
	1983	.44	1.8	13
29105 - Nash/Kentley	1986	.38	1.1	1
	1985	.33	1.0	0
29114 - Vickers/East 18th	1986	.33	1.2	3
29118 - Main W./Hwy. 403	1986	.41	1.6	9
	1985	.42[4]	1.1	3

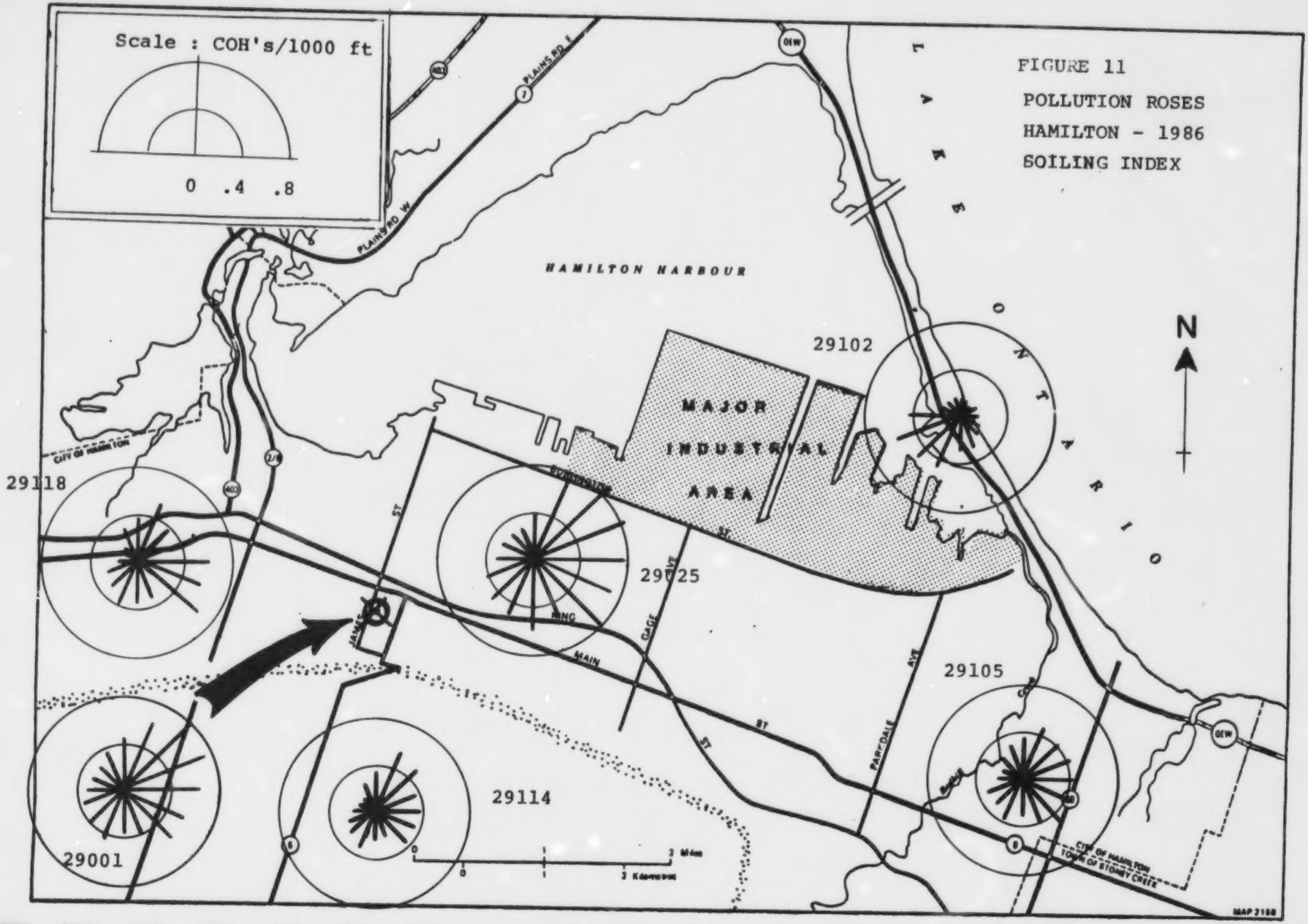
[9] - Numerical exponent refers to number of months sampled when less than 12.
* - 29008 moved to 29102 in October 1984.

FIGURE 10

SOILING INDEX YEARLY TREND

HAMILTON 1971 – 1986




Scale : COH's/1000 ft
0 .4 .8
FIGURE 11
POLLUTION ROSES
HAMILTON - 1986
SOILING INDEX
HAMILTON HARBOUR
LAKE ONTARIO
N
MAJOR INDUSTRIAL AREA
29102
29118
29125
29105
29114
29001
PLAINS RD W
PLAINS RD E
CITY OF HAMILTON
BURLINGTON ST
MAIN ST
PARKDALE AVE
GAGE AVE
RING
0 3 Miles
0 3 Kilometres
CITY OF HAMILTON
TOWN OF STONEY CREEK
MAP 2188

Soiling index pollution roses are given in Figure 11. While the downtown and Barton Street stations show the highest concentrations, and do show peaks under northeast winds up to about 0.8 COH's, these averages were inflated by inversion-time measurements which were largely traffic related. Both the east 29105 (Nash/Kentley) and west 29118 (Main West) stations do not show peaks pointing at the industries. The east station is well located, being remote from traffic, while the west station is adjacent to the Highway 403 cutoff. The southeast peaks at the station near the 403 point to this roadway. The mountain station 29114 (Vickers/E 18th) showed low averages from all directions and a slight lower-city influence is noted for northeast winds. The Beach station, although closest to the industrial area, shows the lowest levels. It does continue to show southwest peaks (from industry); however, they are half of what they were at the old North Park station, and the new station still has the QEW and Beach Blvd. upwind during southwest winds. Peaks at rush hours are still evident in the data.

It is important to note that while traffic appears to affect the soiling index measurement more than industry, industrial emissions may still be contributing. Another fine particulate monitor, also measuring particles less than 10 microns and known as a dichotomous sampler, is currently being used on an experimental basis. It correlates fairly well to suspended particulate results, while soiling index correlates poorly. This is probably explained by the fact that the dichotomous sampler and suspended particulate methodologies involve weight determinations, while the soiling index uses the light scattering properties of particles. Both the suspended particulate results and dichotomous results do show industrial area contributions to particulate levels, especially during inversions. The soiling index measurement however, will be retained because it is the only practical method for measuring hourly concentrations.

4.2.3 Dustfall

Dustfall is that material which settles out of the atmosphere by gravity. It is collected in plastic containers during a 30 day exposure time. The collected material is weighed and expressed as a deposition rate of grams/square meter/30 days. The significance of observations is restricted to relatively local areas.

Dustfall levels in 1986 (Table 5) remained similar to those of previous years. Figure 12 depicts dustfall isopleths, and shows that a small portion of the lower city and the Beach Strip near the industrial area was encompassed by the 9.0 grams/m^2/30 days contour which represents twice our objective. Conditions in this area, for the most part were quite poor. None of the 15 stations met the yearly objective.

TABLE 5

DUSTFALL 1986

UNITS - GRAMS/SQ. METRE/30 DAYS

Ontario Objectives - 1 month avg - 7.0
1 year ave - 4.5

	Annual Average 1984	1985	1986	Maximum 1986	Number of Months Above Objective 1986
29001 Hughson/Hunter	6.8	8.0	6.2	11.0	5
29006 Queenston	4.9	6.3	6.4	12.2	5
29009 Kenilworth	5.9	5.7	4.6	7.5	2
29010 Burlington/Ottawa	21.0	16.9	19.9	26.9	12
29011 Burlington/Leeds	14.0	12.5	14.1	20.0	12
29012 Burlington/Wellington	9.8	9.5	8.8	12.9	10
29017 Chatham/Frid	9.9	8.8	9.7	19.8	10
29025 Barton/Sanford	7.2	6.2	5.9	8.3	5
29030 Camden/Mohawk	5.7	5.0	5.1	8.2	1
29031 Concession/Upper Sherman	8.0	7.7	7.1	10.2	6
29036 Roosevelt/Beach Rd.	17.4	16.7	18.8	22.0	12
29044 Wark/Beach Blvd.	8.4	8.6	9.3	12.5	9
29082 Leaside Rd.	8.0	7.0	8.1	12.1	7
29084 Rembe/Beach Blvd.	9.6	10.9	10.2	17.1	11
29102 Beach Blvd.	-	6.1	5.6	13.6	2

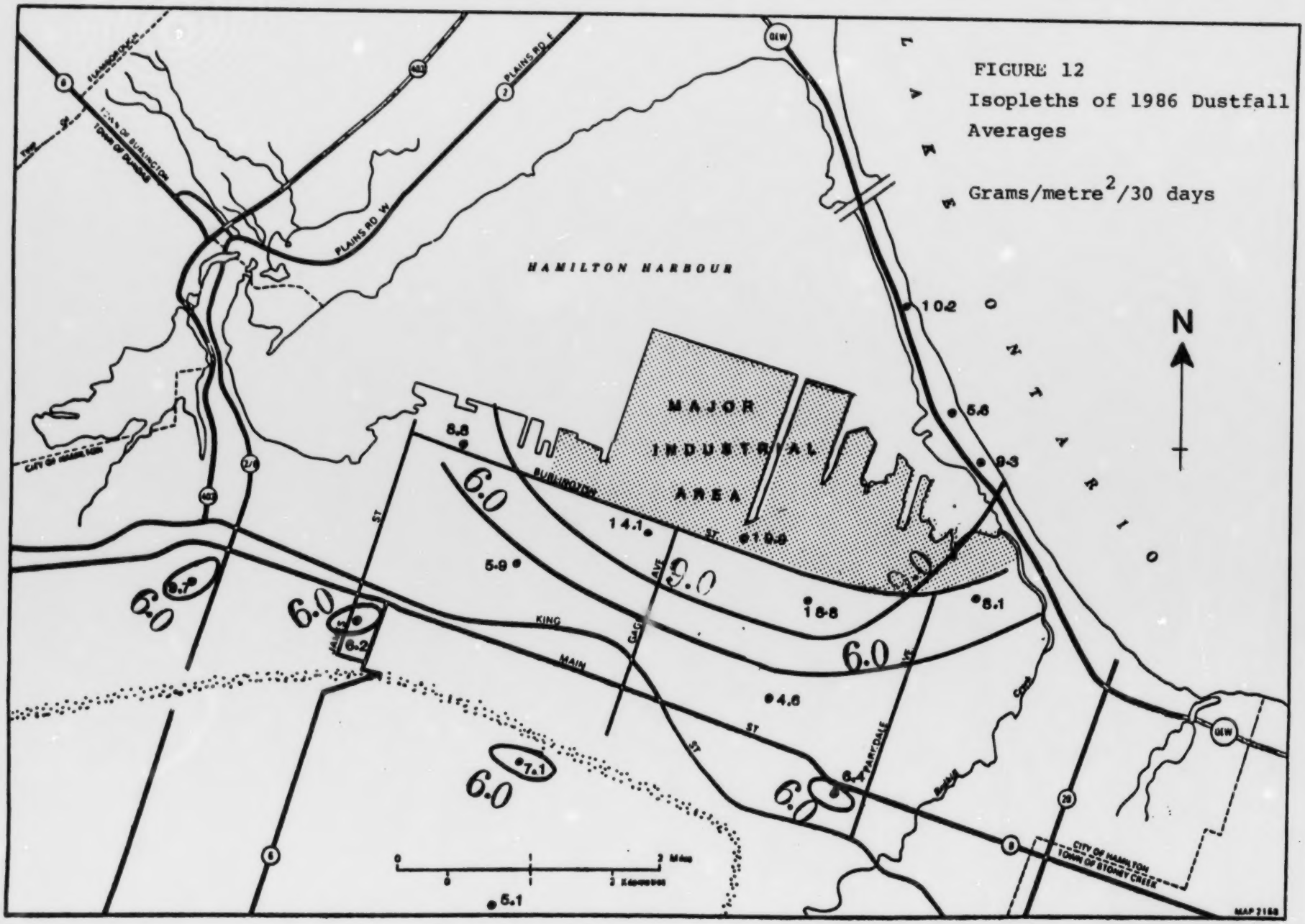


FIGURE 12
Isopleths of 1986 Dustfall Averages

Grams/metre^2/30 days

As with the suspended particulate contour maps, the dustfall contour maps are not strictly definitive representations of conditions city wide. Local influences affect some of the stations and the measurement is very imprecise. As well, some of the small contours drawn have no scientific validity. They are only drawn to indicate that particular stations are subject to local influences, unrepresentative of the general area.

Dustfall objectives are based on visible deposit of dust rather than health effects. Figure 4 shows that the levels throughout the city have remained virtually unchanged throughout the 1970's and 1980's, a significant observation considering the considerable reductions in industrial process emissions and the correspondingly large reductions in suspended particulate concentrations noted in the same graph. Fugitive dust sources such as road dust, stock piles, unpaved areas, vehicle emissions, etc. are probably important in explaining this observation.

Road traffic is a major source of the dust at several of the stations. The locations on Concession Street at Upper Sherman (29031) and Mohawk Road at Camden (29030) recorded higher than expected loadings, probably due to the heavy traffic which passes directly by the stations. On Ottawa Street (29010), construction activities at Dofasco have resulted in extremely high concentrations being observed, of which a large portion can probably be ascribed to increased heavy truck traffic and quantity of dirt tracked onto the street near the station. The station at Chatham/Frid (29017) is also probably significantly affected by local fugitive sources such as road traffic and unpaved lots.

Control efforts such as the use of chemical sealants, road paving and road washing have taken place within some company properties in the industrial area to control fugitive dust emissions. However, no significant improvement in overall dustfall has occurred. Measurements on company properties indicate that fugitive dust emissions are still considerable. More intensive control efforts will be necessary. These may include more landscaping and measures to reduce dirt trackout onto streets.

4.3 Sulphur Dioxide

Most sulphur dioxide (SO_2) emissions in Hamilton stem from industrial sources. A smaller portion is accounted for by fuel burning in domestic space heating. Data for six stations are summarized in Table 6, which lists objective values that are based on vegetation damage (hourly and yearly) and health effects in conjunction with suspended particulate (daily).

TABLE 6

SULPHUR DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .25
24-hour - .10
1-year - .02

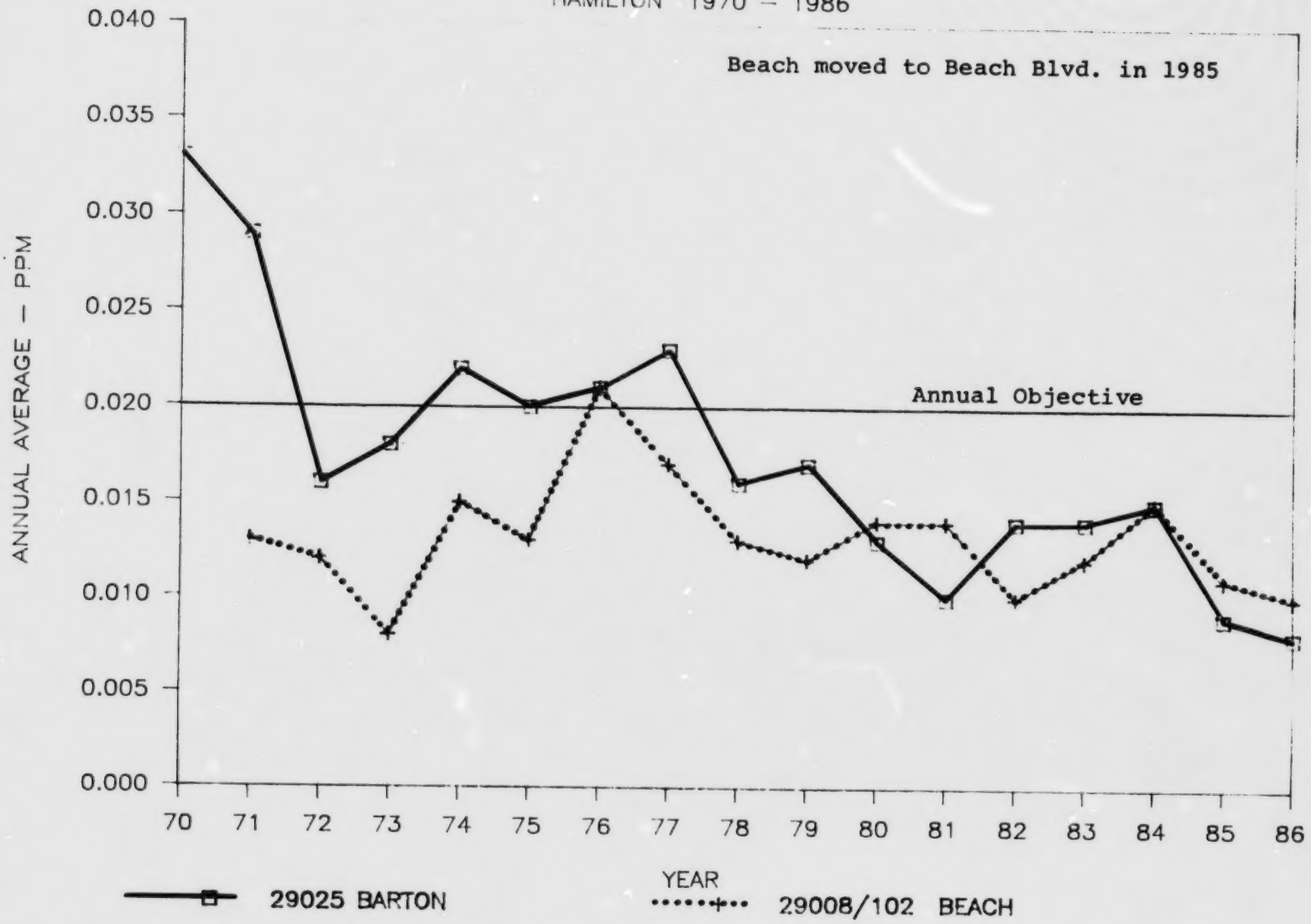
		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1986	.010	.12	.07	0	0
	1985	.011	.12	.06	0	0
	1984*	.015	.13	.07	0	0
	1983	.012	.11	.06	0	0
29025 - Barton/ Sanford	1986	.008	.14	.05	0	0
	1985	.009	.11	.06	0	0
	1984	.015	.18	.07	0	0
	1983	.014	.15	.04	0	0
29105 - Nash/ Kentley	1986	.006	.17	.05	0	0
	1985	.004	.16	.02	0	0
29114 - Vickers/ East 18th	1986	.009	.11	.05	0	0
29118 - Main W./ Hwy. 403	1986	.007	.24	.04	0	0
	1985	.005[6]	.06	.03	0	0

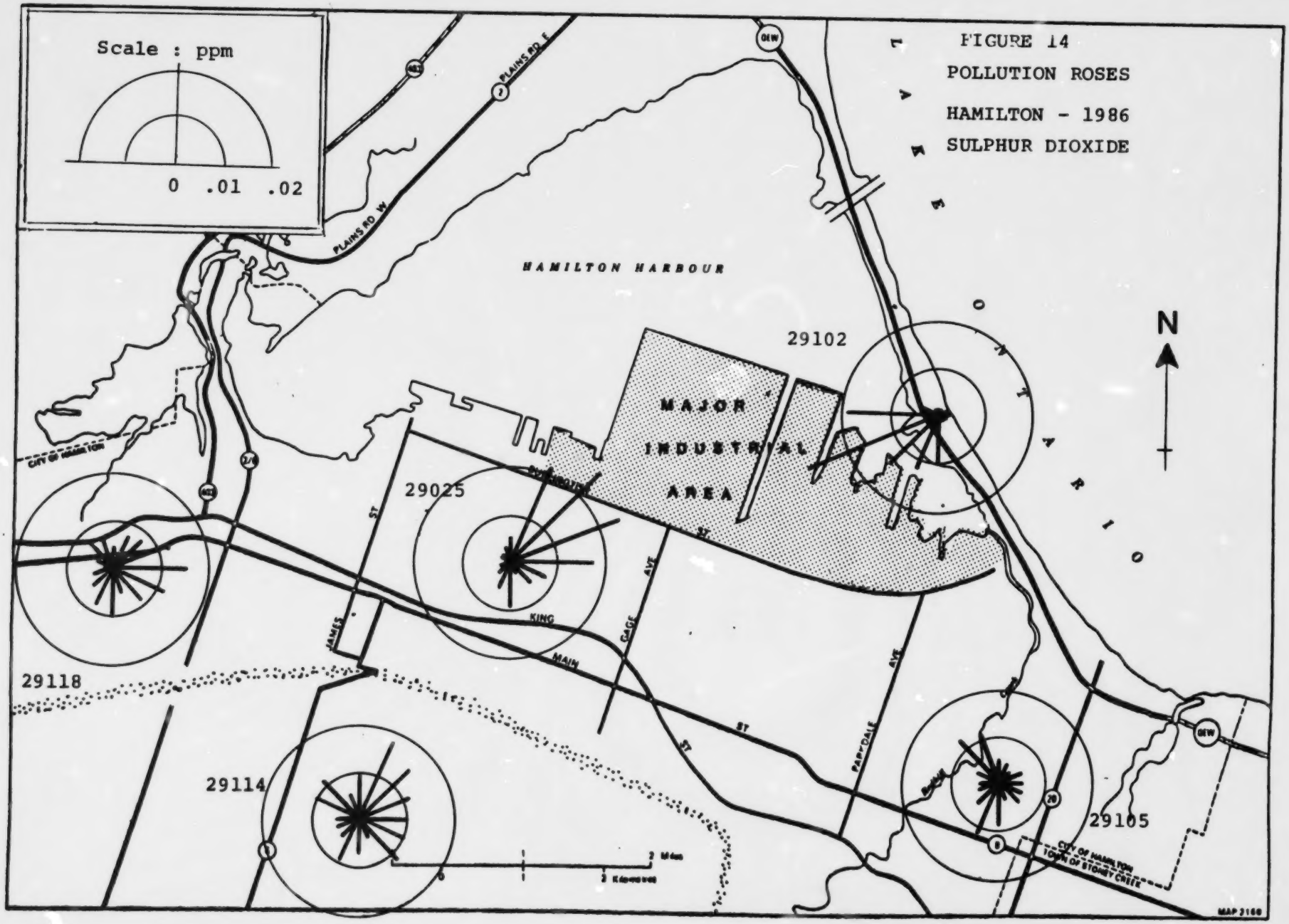
* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

FIGURE 13

SULPHUR DIOXIDE YEARLY TREND

HAMILTON 1970 – 1986




Scale : ppm
0 .01 .02
FIGURE 14
POLLUTION ROSES
HAMILTON - 1986
SULPHUR DIOXIDE
HAMILTON HARBOUR
MAJOR INDUSTRIAL AREA
29102
29025
29118
29114
29105
N
PLAINS RD E
PLAINS RD W
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK

Sulphur dioxide trends from the Barton and Beach stations since 1970 are illustrated in Figure 13. In 1986, as in the past several years, the concentrations were acceptable based on the yearly objective and there were no readings above the hourly or daily objectives. The three new stations in the east end, west end and mountain showed even lower levels, indicating the smaller industrial influence at these locations.

The pollution roses for the stations are given in Figure 14 and confirm that the industrial area is the prime source of SO_2 in the city but that the effect is mainly limited to the area near the industries. The east, west and mountain stations show only small industrial influence. Local space heating likely affects these stations.

4.4 Total Reduced Sulphur

These gases are comprised of hydrogen sulphide (H_2S), the "rotten egg" gas and other sulphur compounds and the mixture is referred to as total reduced sulphur (TRS). There are no general objectives for TRS, however an hourly objective for H_2S of 20 ppb (based on its odour threshold) may be compared to the observed values since most emissions are thought to contain H_2S. Both Barton/Sanford and North Park/Beach Blvd. monitored this pollutant continuously and a new TRS analyzer was installed at the mountain station 29114 (Vickers/E 18th) in October. The data is summarized in Table 7.

The major sources of hydrogen sulphide and related sulphur compounds are the steel industry's coke ovens and related by-products operations, certain slag quenching processes and under upset conditions, a local manufacturer of carbon black. The sewage treatment plant is another potential source of odours but only during certain upset conditions.

In 1986, there were 17 hours exceeding the H_2S objective at Beach Blvd., 12 hours at Barton/Sanford and 4 hours on the mountain at Vickers/E 18th (over three months). Historical trends of hourly concentrations over 10 ppb are illustrated in Figure 15. This concentration is significant in that H_2S can generally be smelled at this level. The Barton St. station shows a generally steady decline in TRS exceedences. The Beach location also seems to show a decline but also varies widely from year to year.

Not surprisingly, the TRS pollution roses for the three stations given in Figure 16 point strongly toward the industrial area. Special monitoring surveys have and are continuing to be carried out to determine main sources of the elevated ambient concentrations in order to plan the most effective abatement strategies.

TABLE 7

TOTAL REDUCED SULPHUR

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 20 (Hydrogen Sulphide)

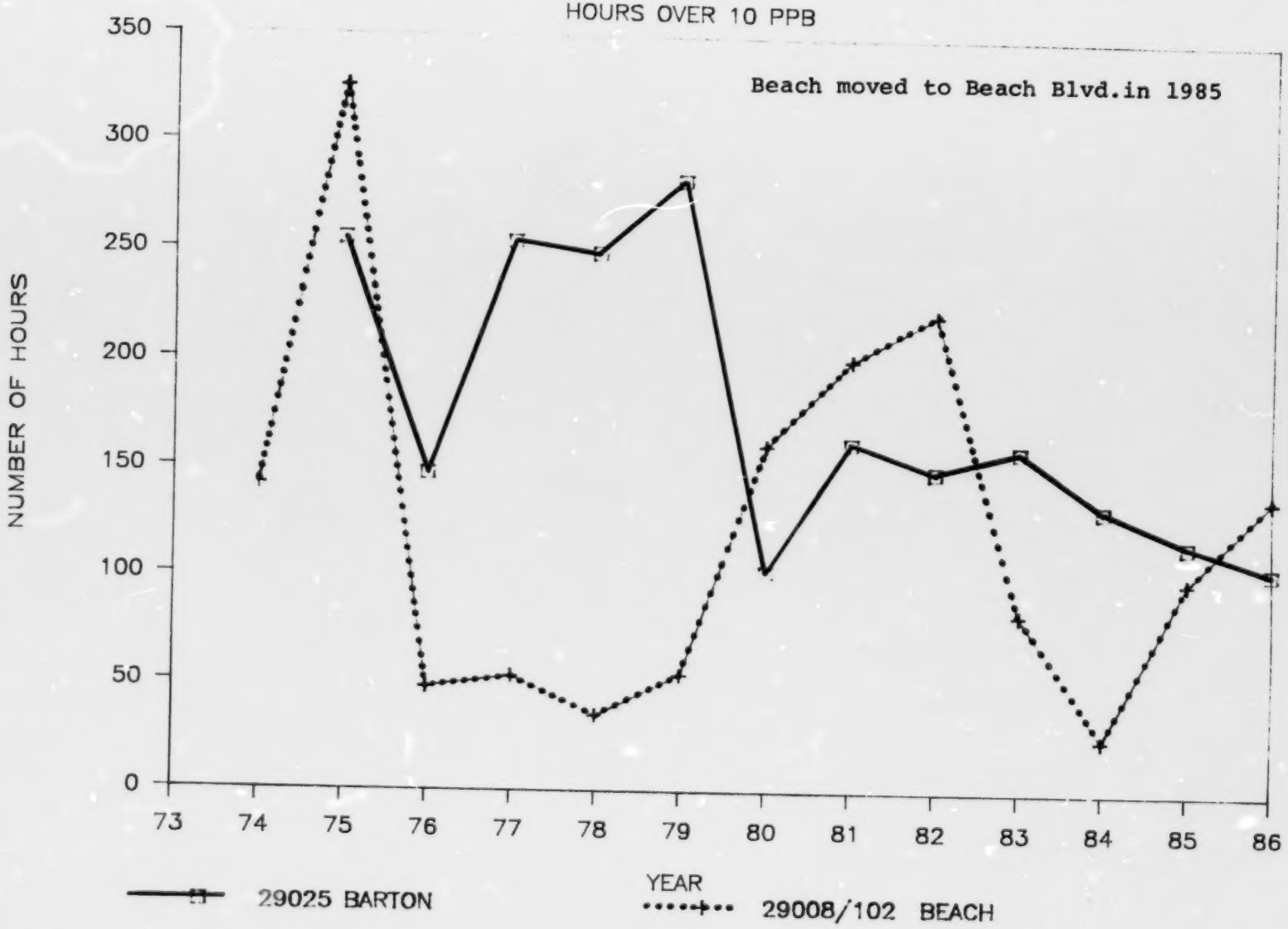
		Annual Average	Maximum	No. of Hours Above Objective
29008 - North Park/ 29102 - Beach Blvd.	1986	1.3	42	17
	1985	1.0	37	15
	1984*	0.9	41	9
	1983	1.2	30	9
29025 - Barton/ Sanford	1986	1.4	64	12
	1985	1.4	56	16
	1984	1.8	44	20
	1983	1.4	48	30
29114 - Vickers/ East 18th	1986	0.9[3]	24	4

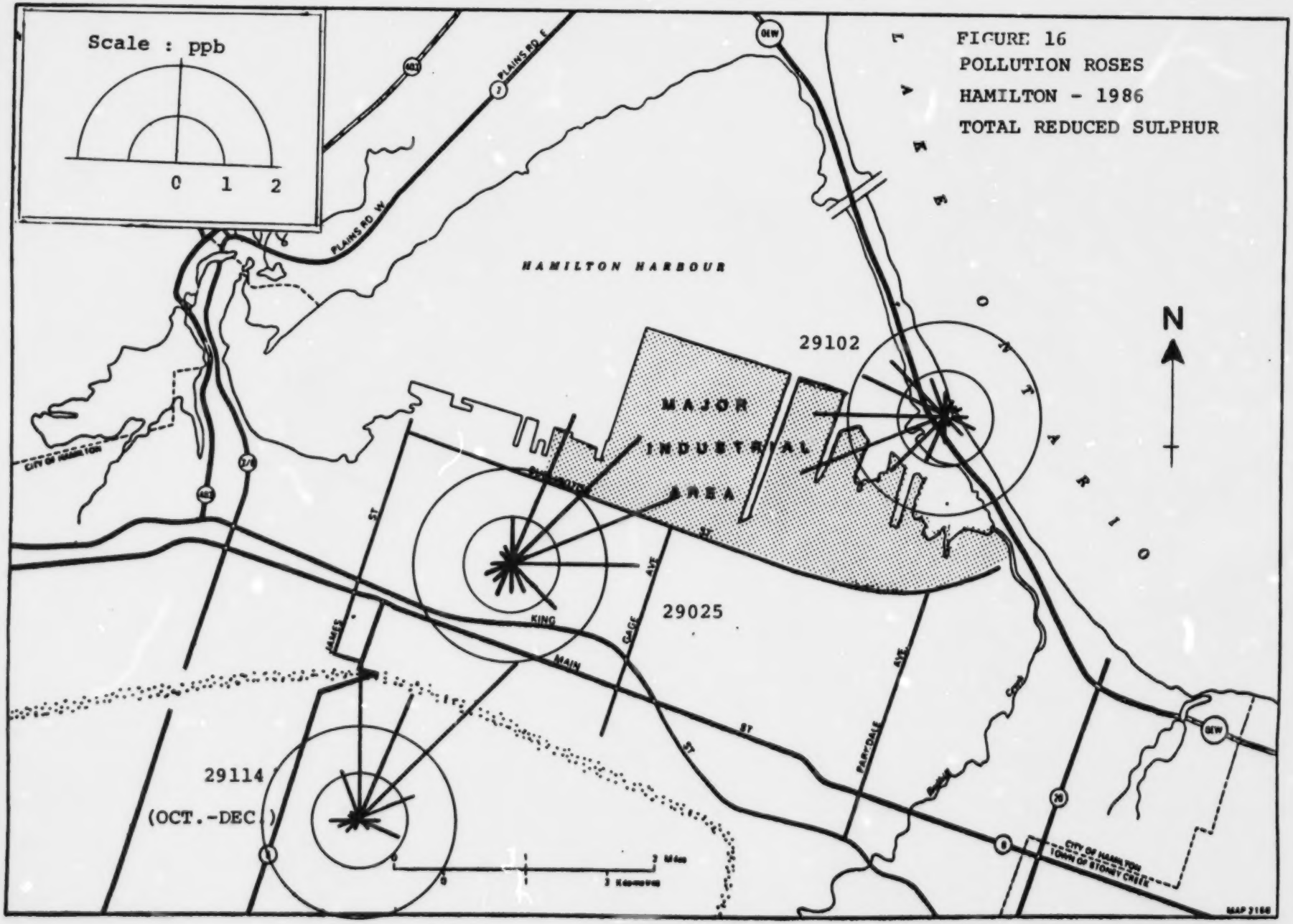
*29008 moved to 29102 in October 1984.
3 - Three months of data (Oct-Dec).

FIGURE 15

TRS EXCEEDENCE TREND – HAMILTON

HOURS OVER 10 PPB




Scale : ppb
0 1 2
FIGURE 16
POLLUTION ROSES
HAMILTON - 1986
TOTAL REDUCED SULPHUR
HAMILTON HARBOUR
LAKE ONTARIO
N
MAJOR INDUSTRIAL AREA
29102
29025
29114
(OCT.-DEC.)
PLAINS RD E
PLAINS RD W
KING
MAIN
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF ANCASTER

Programs are underway to reduce TRS emissions. Stelco has replaced the direct cooling towers on coke oven by-products plants. One was replaced in 1985 and the other was replaced in April, 1987. Both Stelco and Dofasco are modifying their slag quenching techniques to reduce TRS formation. Domtar is initiating a comprehensive control program which is under the direction of a Control Order.

4.5 Carbon Monoxide

The major source of carbon monoxide is the automobile although there are also some contributions from industry. Due probably to automotive emission controls, the levels measured at Barton Street decreased greatly since the 1970's (Figure 17). In 1986, the levels were similar to the previous few years and were well below the objectives which are based on health effects. Data are given in Table 8.

A new carbon monoxide analyzer was installed in the North Park station in January 1984. Concentrations at North Park throughout 1984 and at Beach Blvd. in 1985-86 were lower than at Barton Street, explained by the fact that the high speed traffic on the QEW generates less carbon monoxide than the low speed traffic on Barton Street[3], and that the Beach Blvd. traffic load is much less than Barton Street - almost half[4].

The pollution roses given in Figure 18 indicate that southeast quadrant winds (from the intersection of Barton and Sanford Streets) yield the highest averages at Barton, while Beach Blvd.'s highest averages (albeit very low) were from the southwest.

4.6 Oxides of Nitrogen

The primary source of oxides of nitrogen are high temperature combustion sources including the automobile. The most abundant oxides are nitric oxide (NO) and nitrogen dioxide (NO_2). Nitric oxide is a direct emission which is then oxidised in the atmosphere to form nitrogen dioxide. Both pollutants were monitored continuously at Barton/ Sanford, Main West, and Beach Blvd. At each station, a single instrument makes measurements of NO, NO_2 and total nitrogen oxides. Nitric oxide is measured directly, and the total oxides are measured by internally converting all other nitrogen oxides to nitric oxide. The instrument then determines nitrogen dioxide to be the difference between the first two measurements.

Objectives exist only for nitrogen dioxide and these are based on odour threshold levels (hourly) and health effects (24-hourly). Other adverse effects occurring at much higher levels include vegetation damage, reduced visibility and corrosion of metals. The objectives were not exceeded in 1986 similar to previous years.

TABLE 8

CARBON MONOXIDE

UNITS - PARTS PER MILLION

Ontario Objective: 1-hour - 30
8-hour - 13

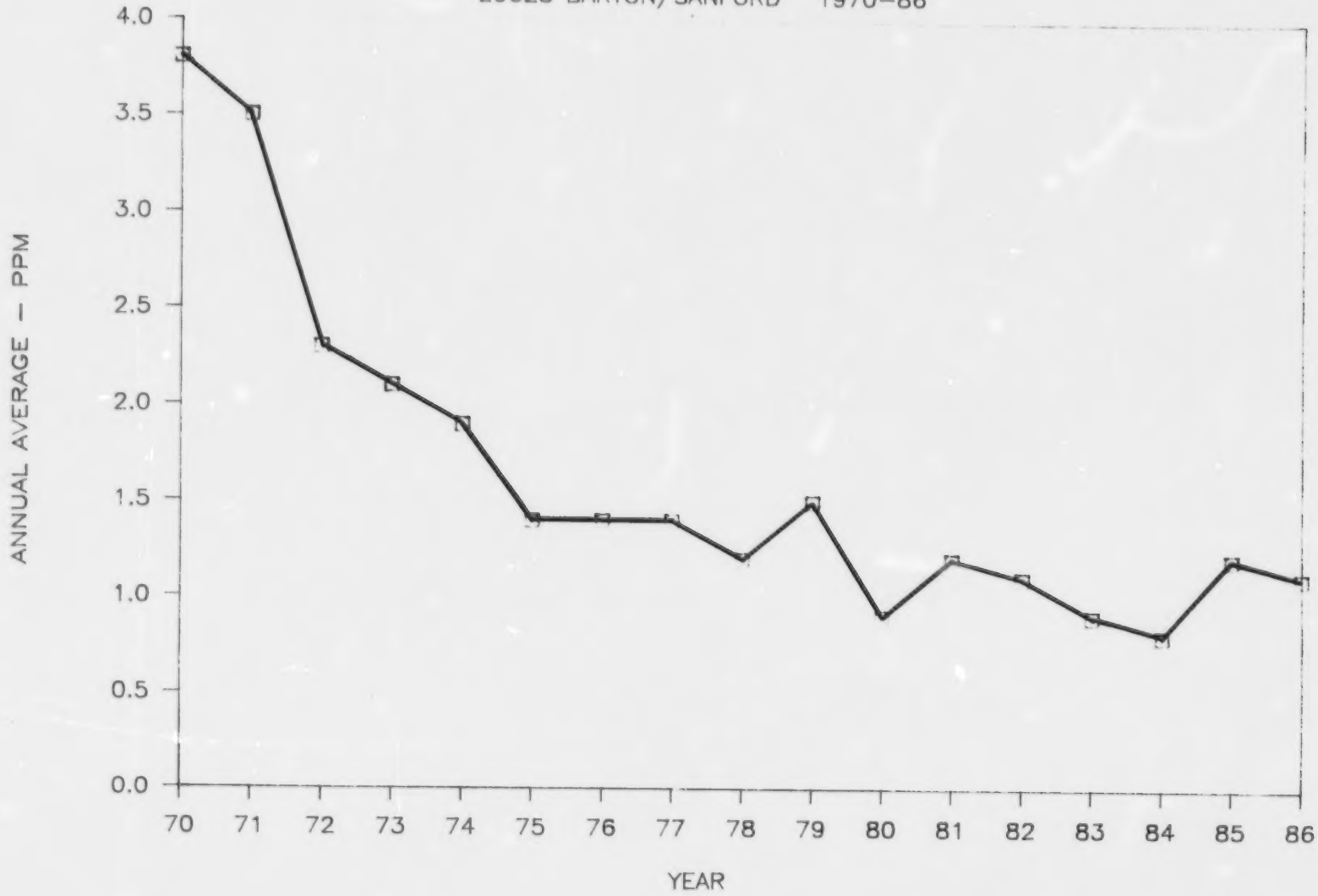
		Annual Average	Maximum 1-hour	Maximum 8-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 8-hour
29008 - North Park/ 29102 - Beach Blvd	1986	0.3	7	2	0	0
	1985	0.3	7	3	0	0
	1984*	0.3	5	2	0	0
29025 - Barton/ Sanford	1986	1.1	12	6	0	0
	1985	1.2	10	4	0	0
	1984	0.8	16	6	0	0
	1983	0.9	12	6	0	0

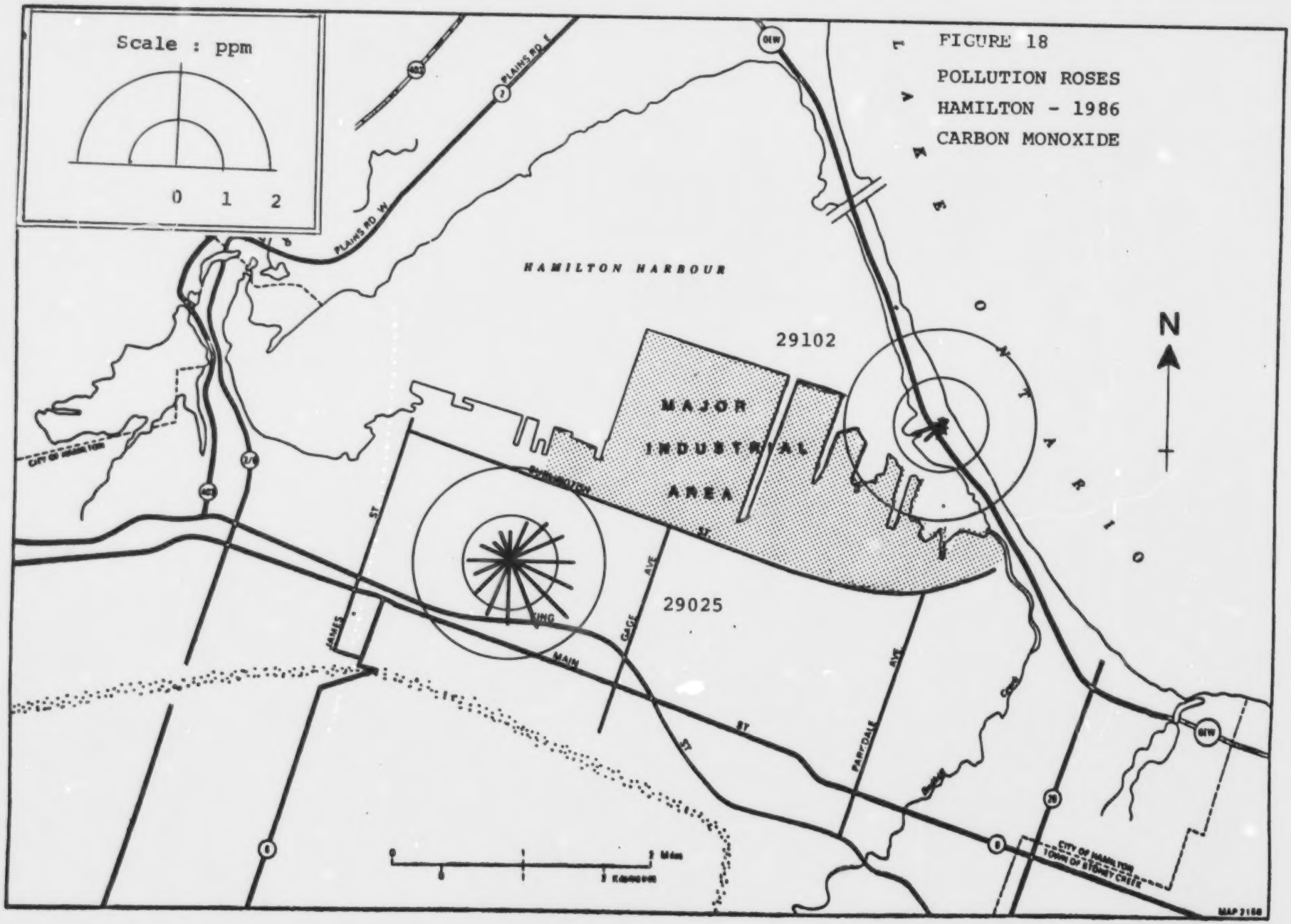
*29008 moved to 29102 in October 1984.

FIGURE 17

CARBON MONOXIDE YEARLY TREND

29025 BARTON/SANFORD 1970–86




Scale : ppm
0 1 2
FIGURE 18
POLLUTION ROSES
HAMILTON - 1986
CARBON MONOXIDE
HAMILTON HARBOUR
29102
MAJOR INDUSTRIAL AREA
29025
N
PLAINS RD E
PLAINS RD W
KING
MAIN
ST
AVE
GAGE
PARKDALE
ONTARIO

Data for nitrogen dioxide are given in Table 9 and yearly trends since 1975 are illustrated in Figure 19. Both Barton and Beach stations showed similar concentrations to previous years but slightly higher than at the new west end site 29118 on Main Street West, indicating a small contribution from industry. A leveling off in concentrations at the two established stations is evident in the trend graph although a small decline is still occurring.

Data for nitric oxide are given in Table 10 and yearly trends for Beach and Barton are given in Figure 21. Note the abrupt decrease in levels at Beach following the move to 29102 in 1985. The station is now obviously less affected by vehicle emissions. The new Main Street West site recorded higher levels in 1986 than the other two; it obviously is being affected by traffic on Main Street West and the Highway 403 cutoff.

Pollution roses for the two measurements are given in Figures 20 and 22. The roses for NO_2 seem to indicate an equal contribution from industry and traffic, particularly by Barton St., but since NO_2 is not a direct emission, sources are difficult to pinpoint. It is clear that NO levels at all stations were due mostly to traffic.

Highest NO levels were measured at 29118 (Main West), and the largest peaks point towards the Hwy. 403 cutoff and Main St. W. Barton (29025) also shows highest levels for southeast - from the intersection of Barton and Sanford Streets. The southwest peaks for 29102 (Beach Blvd.) point mainly to Beach Blvd. and the QEW, although the industries are also upwind.

Oxides of nitrogen are an important factor in the photochemical production of ozone which will be discussed in the next section of this report.

4.7 Ozone

Oxidants are produced by photochemical reactions involving oxides of nitrogen, hydrocarbons and sunlight. Ozone accounts for most of the oxidants produced. The sources of the precursor pollutants are mainly industrial and automotive. The rate of oxident production is dependent on quantity of precursor pollutants, temperature and intensity of sunlight.

Ozone is known to cause respiratory problems, and at very elevated concentrations, people can experience adverse health effects. Ozone is also injurious to different types of vegetation including certain tobacco, bean and tomato crops. The one-hour objective for ozone (80 ppb) is based on such vegetation effects.

TABLE 9

NITROGEN DIOXIDE

UNITS - PARTS PER MILLION

Ontario Objectives: 1-hour - .20
24-hour - .10

		Annual Average	Maximum 1-hour	Maximum 24-hour	No. of Times Above Objective 1-hour	No. of Times Above Objective 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1986	.023	.12	.05	0	0
	1985	.023	.08	.06	0	0
	1984*	.026	.09	.07	0	0
	1983	.026	.14	.07	0	0
29025 - Barton/ Sanford	1986	.027	.10	.07	0	0
	1985	.025	.11	.06	0	0
	1984	.029	.13	.06	0	0
	1983	.029	.10	.08	0	0
29118 - Main W./ Hwy. 403	1986	.018	.12	.08	0	0
	1985	.019[6]	.08	.04	0	0

* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

TABLE 10

NITRIC OXIDE

UNITS - PARTS PER MILLION

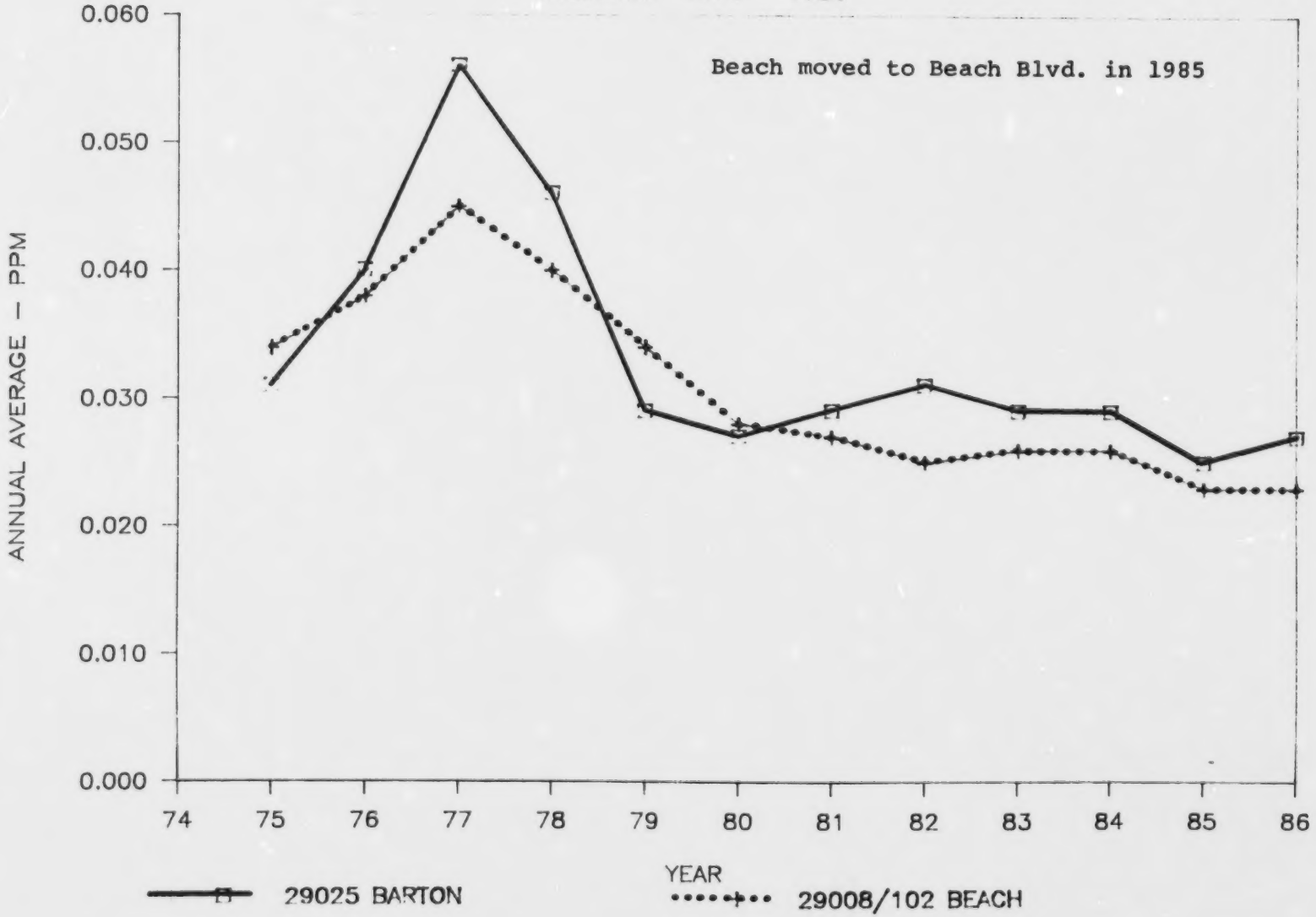
		Annual Average	Maximum 1-hour	Maximum 24-hour
29008 - North Park/ 29102 - Beach Blvd.	1986	.023	.47	.23
	1985	.020	.51	.09
	1984*	.056	.52	.22
	1983	.057	.53	.21
29025 - Barton/ Sanford	1986	.022	.50	.15
	1985	.019	.51	.11
	1984	.019	.41	.12
	1983	.018	.45	.17
29118 - Main W./ Hwy. 403	1986	.029	.53	.20
	1985	.033[6]	.92	.15

* - 29008 moved to 29102 in October 1984.
6 - Six months of sampling (July - December).

FIGURE 19

NITROGEN DIOXIDE YEARLY TREND

HAMILTON 1975 – 1986



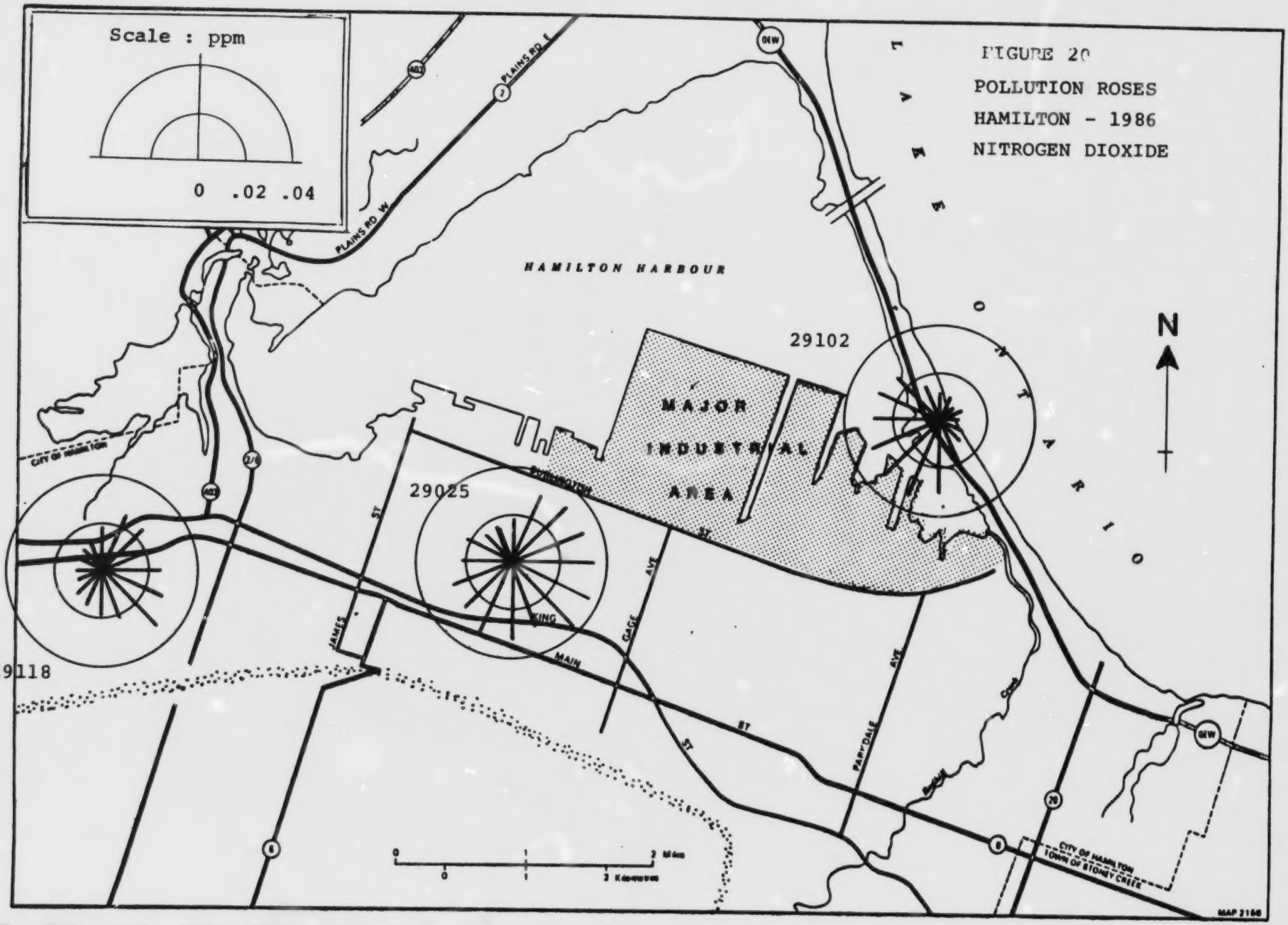
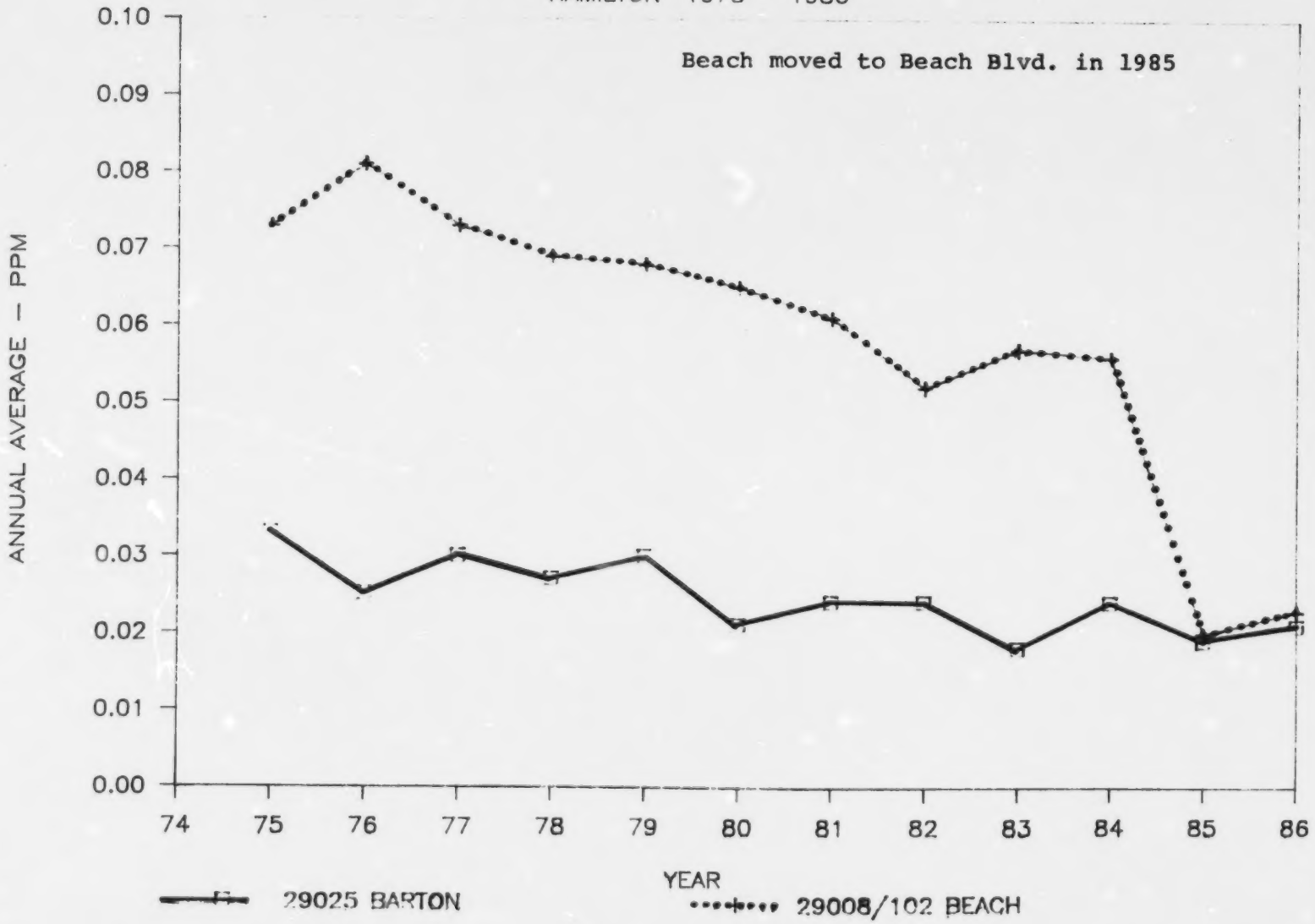


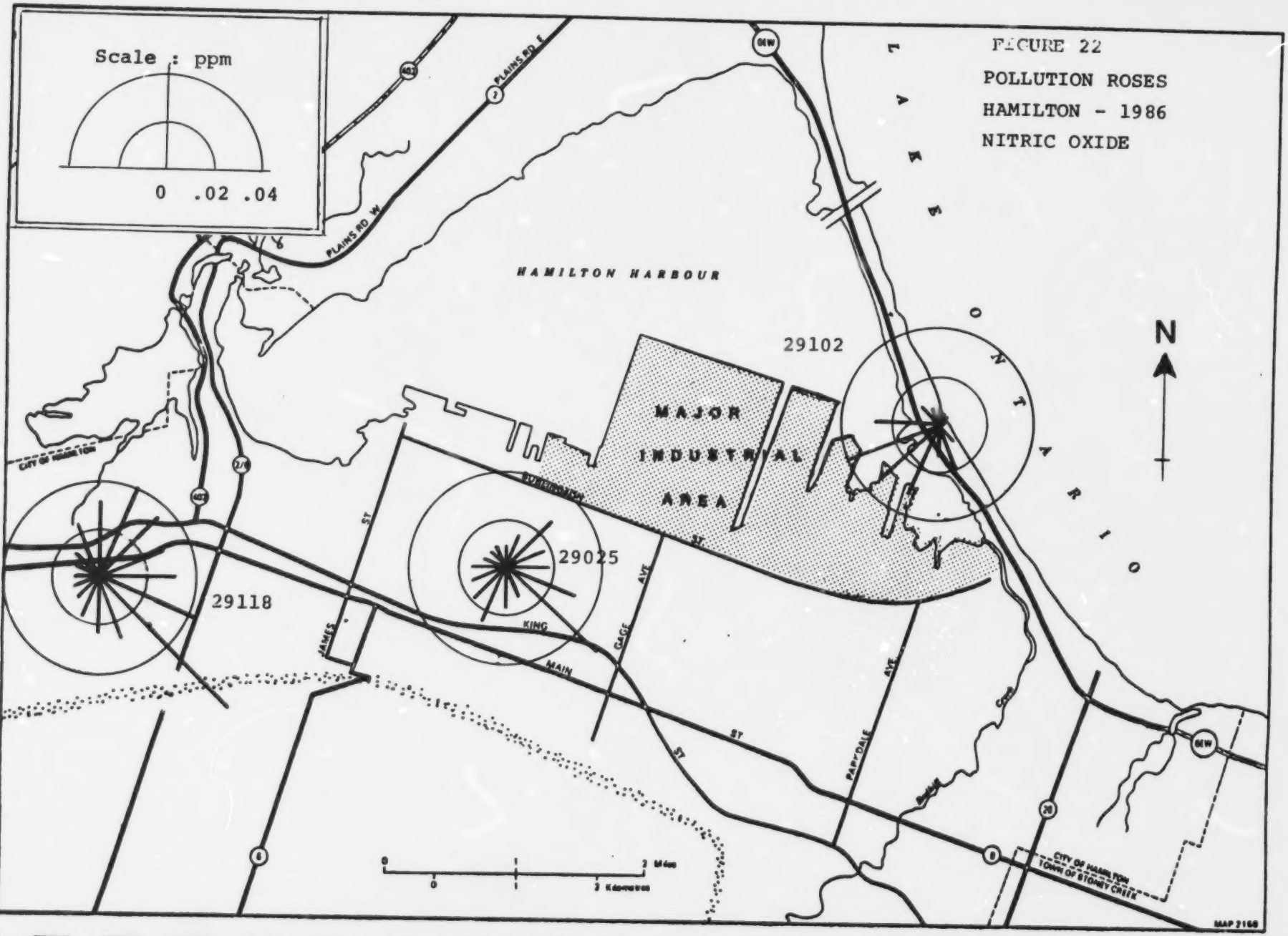
FIGURE 20
POLLUTION ROSES
HAMILTON - 1986
NITROGEN DIOXIDE

FIGURE 21

NITRIC OXIDE YEARLY TREND

HAMILTON 1975 – 1986




Scale : ppm
0 .02 .04
FIGURE 22
POLLUTION ROSES
HAMILTON - 1986
NITRIC OXIDE
HAMILTON HARBOUR
LAKE ONTARIO
MAJOR INDUSTRIAL AREA
29102
29025
29118
N
PLAINS RD E
PLAINS RD W
BURLINGTON ST
KING ST
MAIN ST
JAMES ST
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK
MAP 2168

Ozone concentrations follow very definite annual and daily trends. Highest levels occur during the summer (May - September), and the daily maxima usually occur during mid- afternoon. Both patterns are directly related to temperature and the amount and intensity of sunlight.

Ozone was measured at the Barton Street station, at the new east site 29105 (Nash/Kentley), the west site 29118 (Main West) and mountain station 29114 (Vickers/E 18th). Data is summarized in Table 11 while yearly trends at Barton are illustrated in Figure 23.

In 1986, levels tended to be similar to previous years and fairly uniform City-wide. However, when levels became high, they were high city-wide and concentrations were highest on the mountain. This station recorded the greatest number of hours over the hourly objective of 80 ppb - 34 hours. There were a total of 13 days when at least one station exceeded the objective during the spring/summer. Winds were southwest each time and warm temperatures prevailed.

The origin of the ozone is believed to be the United States. The pollution roses in Figure 24 computed for the May - September period confirm that highest concentrations occurred under winds from the southwest quadrant. The peaks from these directions are not overly prominent because southwest winds do not automatically yield high ozone levels even during the summer. Low temperatures, lack of precursor pollutants or absence of direct sunlight all reduce ozone formation.

Ozone, hydrocarbons and oxides of nitrogen can be transported over great distances and can be augmented by local sources. However, Hamilton and other major urban areas usually experience lower ozone concentrations than their more rural surroundings during peak occurrences. In fact, the concentrations in Hamilton are among the lowest recorded in Southern Ontario, probably due to the numerous high temperature combustion sources which produce scavengers of ozone such as nitric oxide. Nonetheless, ozone and other oxidants remain a problem which, due to the complexity of their formation and the long range transport phenomenon, will have to be resolved on a national and international rather than local scale.

4.8 Fluoridation

This measurement is a relatively crude assessment used to determine quantities of various fluoride compounds in the ambient air. A lime coated paper is exposed to the atmosphere for one month and is then chemically analyzed for fluoride. The fluoride objectives are based on vegetation damage and for this reason, the objective is more stringent during the growing season. For the period of April 15 to October 15, it is 40 micrograms/100 square centimeters/30 days while for the remainder of the year it is 80.

TABLE 11

OZONE

UNITS - PARTS PER BILLION

Ontario Objective: 1-hour - 80

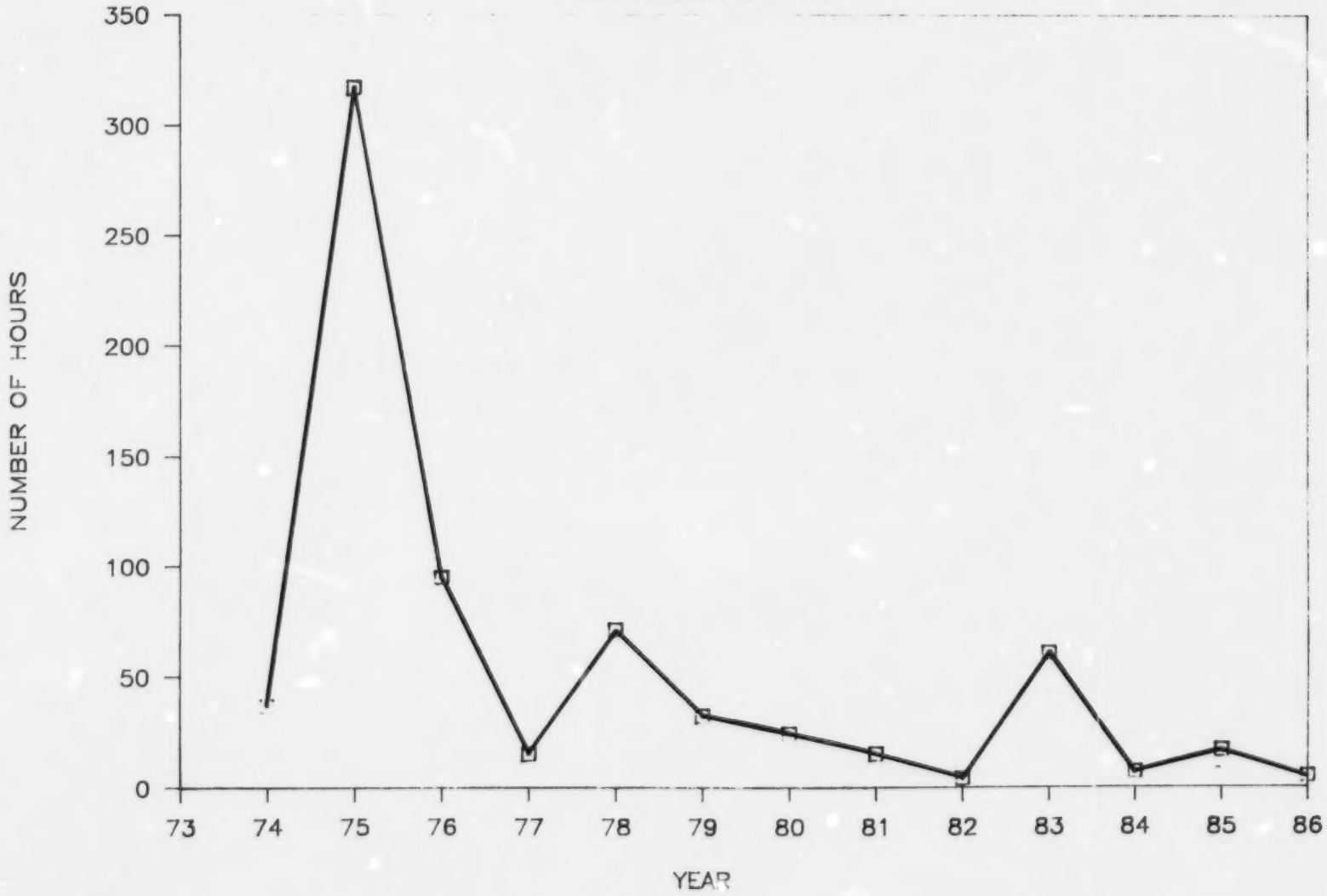
		Annual Average	Maximum - 1 hour	No. of Hours Above Objective
29025 - Barton/ Sanford	1986	16.3	88	5
	1985	19.0	96	17
	1984	18.1	95	7
	1983	18.7	111	61
29105 - Nash/ Kentley	1986	19.2	96	11
	1985	23.0[11]	104	23
29114 - Vickers/ East 18th	1986	20.1	94	34
29118 - Main W./ Hwy. 403	1986	15.0	85	3
	1985	17.9[6]	99	23

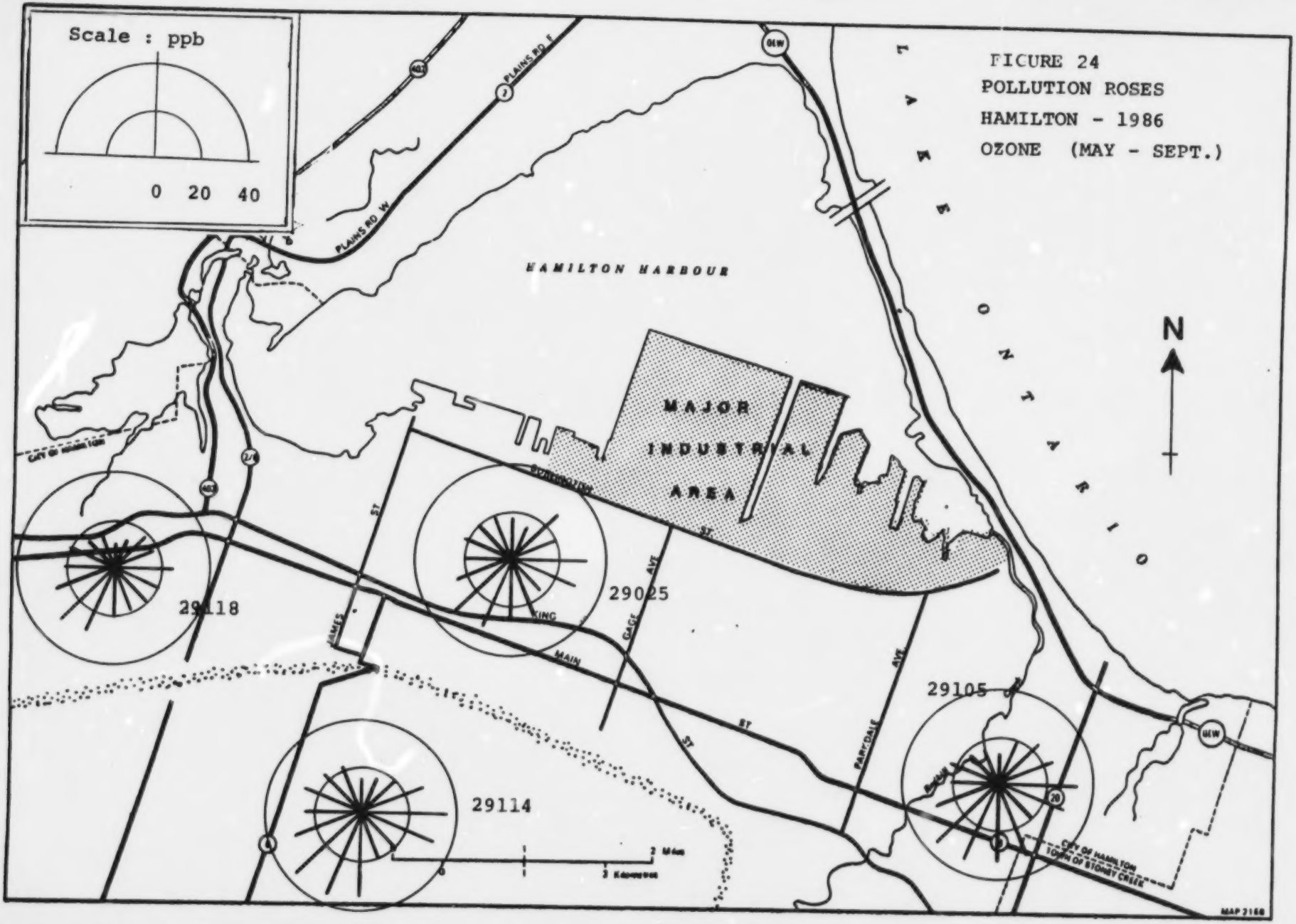
[11] - Numeric exponent refers to number of months sampled when less than 12.

FIGURE 23

OZONE EXCEEDENCE TREND – BARTON/SANFORD

HOURS OVER 80 PPB




Scale : ppb
0 20 40
FIGURE 24
POLLUTION ROSES
HAMILTON - 1986
OZONE (MAY - SEPT.)
HAMILTON HARBOUR
LAKE ONTARIO
MAJOR INDUSTRIAL AREA
N
29118
29025
29114
29105
PLAINS RD W
PLAINS RD E
KING
MAIN
GAGE AVE
PARKDALE AVE
CITY OF HAMILTON
TOWN OF STONEY CREEK

In Hamilton, the major fluoride sources are the basic oxygen furnaces used by the major steel industries which require fluorspar as a fluxing agent. In addition to these process emissions, there are other minor sources such as coal burning, since coal contains trace amounts of fluoride. A brick manufacturing plant at the base of the escarpment near Gage Park is the only non-steel industry source.

Data for 1986 are summarized in Table 12 and the yearly trend since 1970 is illustrated in Figure 25.

The trend graph shows that levels have declined gradually since 1982 following large reductions in concentrations which began in 1971.

In 1986, four new stations were installed increasing the number of fluoride monitors to 12. This increased network permits the drawing of a contour plot of yearly averages, given in Figure 26. A ring can be drawn around the industrial area as shown. The worst station within this area recorded 7 samples above the monthly objectives. However, the 1986 Phytoxicology Assessment Survey given in th Appendix indicated that fluoride injury to silver maple foliage in this area was only in very small amounts.

Station 29058 on a QEW guardrail was inadvertently removed during construction activities. Its elevated readings were probably related to road traffic anyway, and hence it has not been replaced.

From Table 12 and Figure 26, new station 29115 (London/Justine) near Gage Park and the Hamilton Brick Company, recorded the highest fluoride level in the City. All eleven samples exceeded the monthly objectives, most by a large margin.

Elevated fluoride concentrations near brick plants are common. The station was installed only to determine the severity of levels. A 1983 report undertaken jointly by the Ontario Ministries of Environment, Health and Labour concluded that "the maximum additional intake of fluoride resulting from exposure to brick plant fluoride emissions is small. It is concluded that this additional intake could be considered to fall within the normal range of fluoride intake from dietary sources and as such would not be expected to induce health effects in an exposed population" (p. 24).

This report was based on measurements near a Toronto and a Brampton brick plant. Concentrations measured at station 29115 were actually lower than the highest measurements at these two plants. Nevertheless, the West Central Region's Abatement Section are investigating the plant and its emission sources.

TABLE 12

FLUORIDATION RATE - 1986

ALL VALUES IN MICROGRAMS/100 SQ. CM/30 DAYS

Ontario Criteria - April 15 to October 15 - 40
October 16 to April 14 - 80

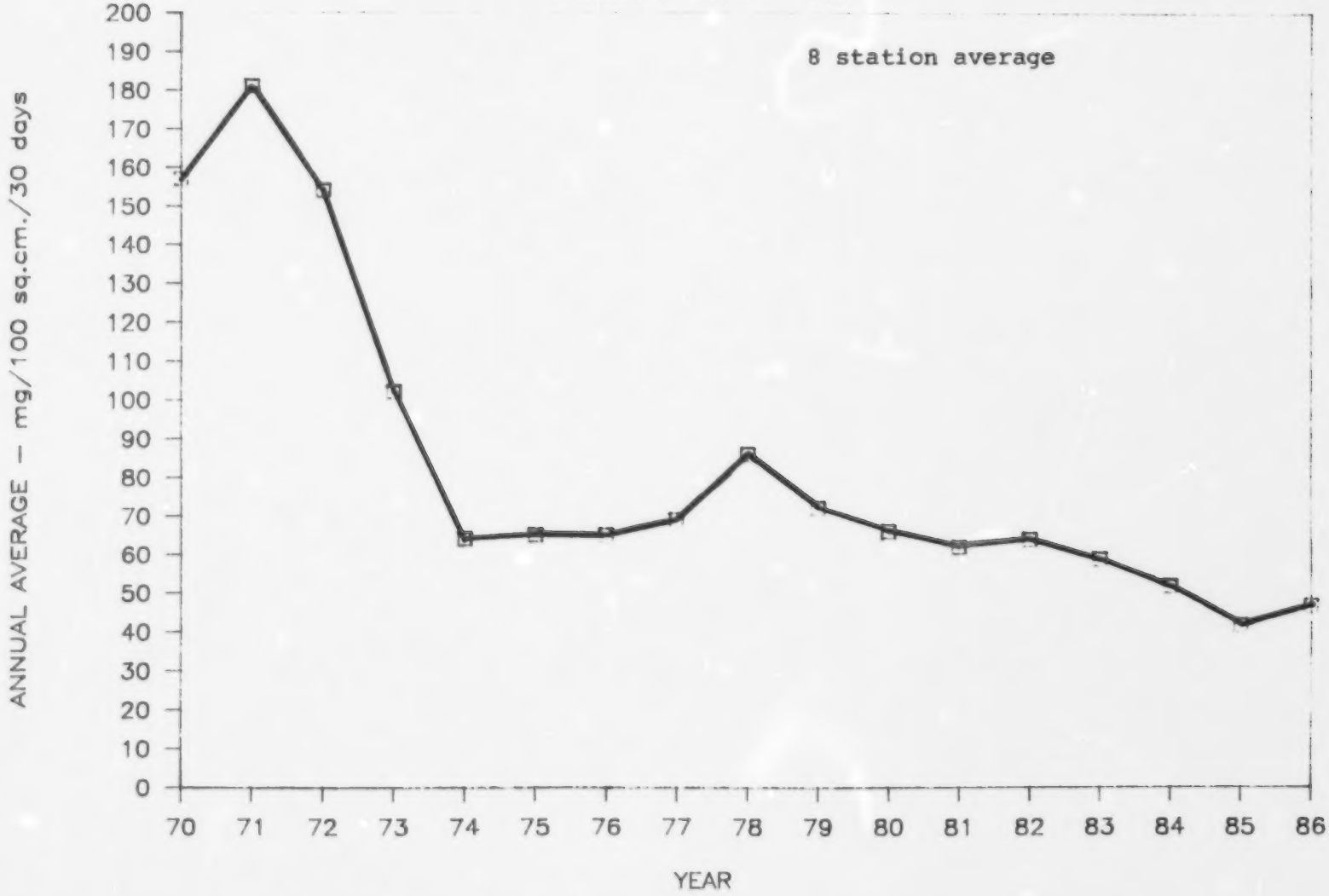
	Annual Average 1984	1985	1986	Maximum 1986	Number of Months Above Objective 1986
29001 Hughson/Hunter	34	26	28	45	1
29012 Burlington/Wellington	22	25	22	28	0
29025 Barton/Sanford	56	34	40	73	4
29054 Beach Rd./Conrad	48	35	44	67	3
29058 Q.E.W./Skyway	85	72	72^{8}	101	4
29059 Burlington/Gage	63	51	59	79	5
29062 Briarwood School/ King St. E.	55	44	54	98	6
29066 Killarney/Beach Blvd.	50	45	54	113	3
29115 London/Justine	-	-	26^{11}	437	11
29116 Dalkeith/Ottawa	-	-	59^{11}	83	7
29119 Morley/Parkdale	-	-	45^{11}	69	2
29120 Dickson/Burlington	-	-	64^{11}	107	7

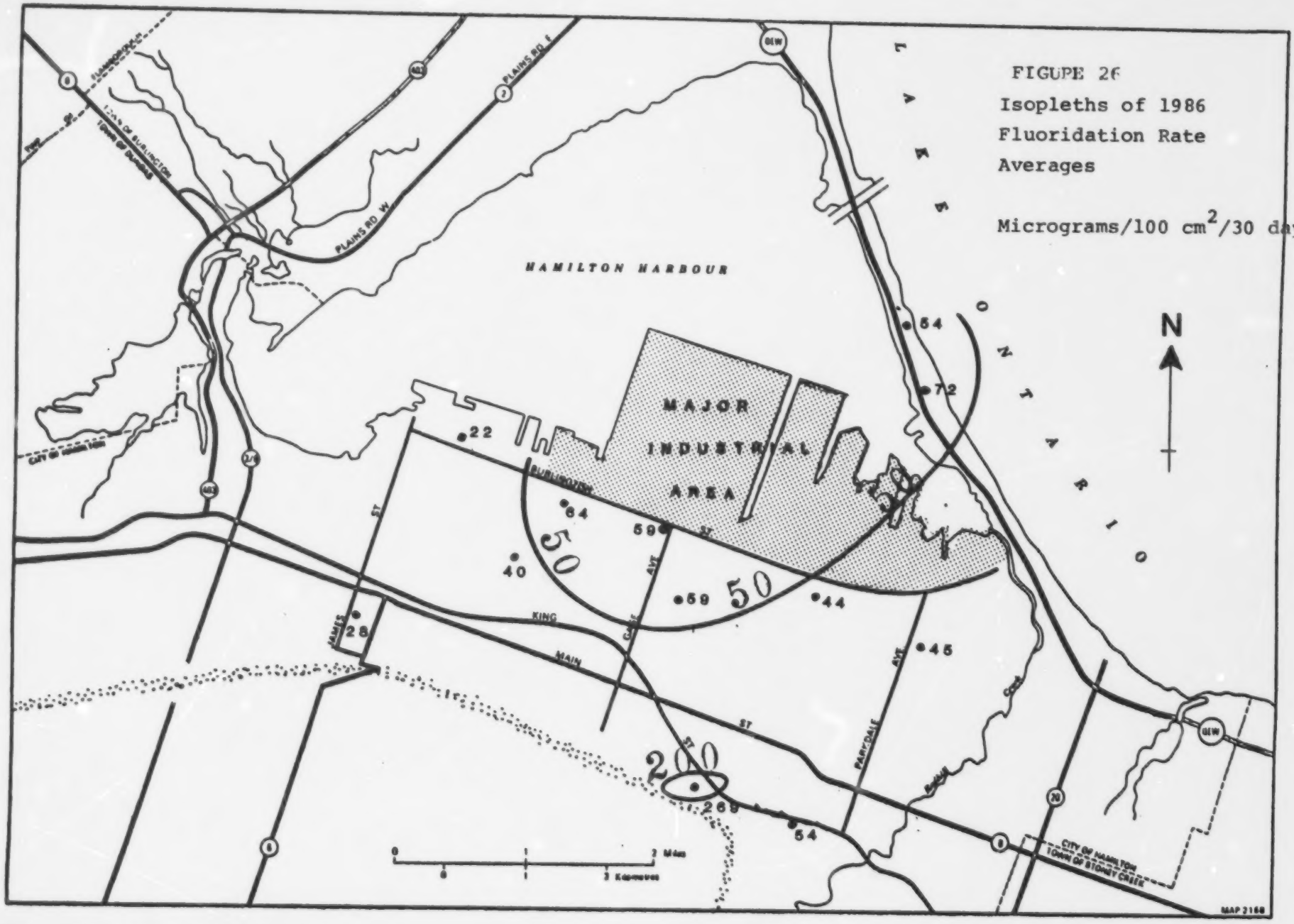
8 - Numeric exponent refers to number of months sampled when less than 12.

FIGURE 25

FLUORIDATION RATE YEARLY TREND

HAMILTON 1970 -- 1986





FIGUPE 26
Isopleths of 1986
Fluoridation Rate
Averages

Micrograms/100 cm^2/30 days

Although human health concerns are not a problem, some vegetation damage in the vicinity of the plant was discovered on silver maple foliage. The Phytotoxicology Section conducted a survey of vegetation near the plant in September 1986. Light to moderate injury to sensitive vegetation (mostly silver maple) was discovered in the vicinity. Injury and fluoride concentrations in the vegetation decreased with distance from the brick plant. The maximum fluoride concentration measured was 820 ug/g, well above the guideline of 35. In contrast, the maximum fluoride level measured in the industrial area was only 31 ug/g in the regular 1986 survey.

5. MOBILE MONITORING SURVEY - 1986

At the request of the West Central Region, Mobile Air Monitoring Unit #1 of the Air Resources Branch undertook an ambient air quality survey in the industrialized sector of Hamilton from October 6 to 17, 1986.

The main aims of this survey were to determine the air quality in this area and if possible, to investigate the air quality in the vicinity of several "targetted" industries north of Burlington Street, namely; the Domtar (Cassidy Works) Tar Plant, Columbian Chemical, and the Stelco and Dofasco steel mills. The results of this survey were also to be compared with a similar study that was conducted in the fall of 1985.

The results of the "targetted" industries follow.

Domtar

Air quality monitoring in the vicinity of the Domtar (Cassidy Works) tar plant on Strathearne Avenue was conducted on five different days in 1986. From these data, the tar plant was found to be a source of total reduced sulphur compounds, aromatics, some chlorinated alkanes, indan and napthalene.

The maximum half-hour average concentrations (MHH) of total reduced sulphur compounds (TRS) measured downwind of this plant ranged from 0.014 to 0.120 ppm (parts per million). From the upwind measurements, the MHH average of TRS was only 0.005 ppm. In 1985, the MHH average for TRS was 0.10 ppm (i.e. similar).

The half-hour Provisional Guideline for total reduced sulphur (0.027 ppm) is not strictly applicable to this study since the guideline was developed for and applies to kraft pulp mills. However, the MHH average of 0.120 ppm for this contaminant measured downwind of this tar plant did exceed the pulp mill guideline value. A request has been forwarded to the Ministry's Standards Development Unit to develop a general guideline for TRS.

The average total organic concentration was found to be approximately 800 ug/m^3 in 1986. In 1985, this average concentration was 700 ug/m^3. In 1986, the alkane, aromatic and chlorinated alkane fractional concentrations were 102 (13%), 598 (74%) and 96 ug/m^3 (12%) respectively. In 1985, these fractional groups were 161 (23%), 484 (69%), and 32 ug/m^3 (5%) respectively.

In 1985, 120 different VOCs (volatile organic contaminants) could be identified. In 1986, this number was increased to 133. Thus considering these factors, the concentrations of VOCs detected downwind of this tar plant were very similar during these two years.

None of the VOCs were detected in concentrations that exceeded applicable Ministry of the Environment Air Quality Standards, Criteria, Guidelines or Provisional Guidelines. Napthalene was identified in the 1985 survey but it was not quantified. In 1986, the field systems were calibrated for this contaminant and half-hour concentrations ranging up to 330 ug/m^3 were detected downwind of this tar plant. Subsequently, in April of 1987, the Ministry of the Environment established a half-hour Provisional Guideline of 36 ug/m^3 for napthalene. This contaminant will be re-monitored in upcoming surveys.

Dofasco

In 1986, Dofasco was monitored during part of one day of the survey. Good dispersion conditions prevailed.

Low organic concentrations were measured averaging only 146 ug/m^3 of which the alkane, aromatic and chlorinated alkane fractions accounted for 57%, 34% and 5% respectively. No applicable standards or guidelines were exceeded for any of the VOC's, or for any of the common contaminants including total reduced sulphur. Concentrations were generally similar to 1985 levels.

Stelco

In 1986, three different monitoring periods were used to acquire data downwind of Stelco. From this air quality data, Stelco was found to be a major source of NOx. The half-hour standard for this pollutant is 0.25 ppm and the MHH average measured was 0.47 ppm. Monitoring upwind of Stelco following the exceedence averaged only .005 ppm. In 1985, the MHH for NOx was 0.22 ppm.

The MHH average for TRS was only .010 ppm compared to .087 in 1985. (These compare to the provisional TRS guideline of .027 ppm for kraft pulp mills only).

For the VOCs detected during the 1986 survey, the average total organic concentration determined was 232 ug/m^3 with an average alkane, aromatic and chlorinated alkane fractional concentrations of 101 (44%), 112 (48%) and 11 ug/m^3 (5%) respectively. An average of only 30 different VOCs were detected in these samples and none had average concentrations in excess of 30 ug/m^3. Only one sample was acquired downwind of Stelco in 1985. Its total VOC concentration was only 117 ug/m^3 with the alkanes accounting for 22% of this total and the aromatics 77%.

Apart from NOx, none of the other applicable Ministry of the Environment Air Quality Standards, Criteria, Guidelines or Provisional Guidelines were exceeded by the contaminants measured downwind of this source.

Columbian Chemicals

From the two days of monitoring in the vicinity of Columbian Chemical during the 1986 survey, low concentrations were measured and the results were found to be characteristic of an urban environment with the lower alkanes and carbon monoxide being the dominant contaminants measured. Similar results were found during the 1985 survey.

No applicable Air Quality Standards, Criteria, Cuidelines or Provisional Cuidelines were exceeded or even approached by the contaminants measured downwind of this source in 1985 or 1986.

General Air Quality in the Industrial Area

During the 1986 survey, air quality data acquired during 12 different monitoring periods were considered to be characteristic of the general environment in the industrial area of Hamilton. From the many hours of data (mostly nighttime monitoring) none of the applicable Ministry of the Environment Air Quality Standards, Criteria, Guidelines or Provisional Cuidelines were exceeded for any of the measured contaminants. TRS concentrations ranged from zero to .024 ppm and NOx ranged from .04 to .09 ppm.

The VOC average concentration was determined to be 169 ug/m^3 with the alkane, aromatic and chlorinated alkane fractions accounting for approximately 50, 35 and 10% of this total respectively.

In 1985, the air quality data acquired at the Pier 24/25 and Harvester sites were also deemed to be characteristic of the general environment in the industrial area of Hamilton. Nighttime inversion conditions existed in 1985 and hence more elevated concentrations were measured during that period than in 1986. For example, the 1985 maximum one-hour averages for TRS and NOx measured at the Harvester site were 0.22 and 0.22 ppm respectively and for the Pier 24/25 site, these were 0.026 and 0.44 ppm respectively. At the Harvester site in 1985, the average total organic concentration was determined to be 524 ug/m^3 and at Pier 24/25, 75 ug/m^3.

In conclusion, very little difference was detected between the 1986 and the 1985 data sets. Napthalene, TRS and NOx still remained an environmental concern in the industrial sector of Hamilton.

6. DISCUSSION

The main air pollution problem in Hamilton, apart from occasional odours and dust fallout in the industrial area, is short-term pollution build-ups during the spring and fall due to the presence of temperature inversions. The sources of the pollution are both vehicle traffic and industry.

During 1986, particulate levels increased slightly at most monitoring stations. This may have been related to an increased amount of "background" particulate which entered the City from distant sources. The Air Pollution Index (API) reached the advisory level of 32 on five occasions, compared to twice in 1985, all during inversion conditions. The city's unique topography makes it very susceptible to inversions during which times pollution build-ups are unavoidable, and therefore, such incidents are likely to recur in the future.

Significantly, soiling index measurements, a measure of fine particles less than 10 microns in size and hence, a more health related parameter, have been shown to be primarily related to traffic sources rather than industry and become particularly acute during inversion conditions, especially adjacent to roadways. Industrial emissions do contribute as well but probably to a lesser degree. Importantly, this conclusion relates to the measurement methodology for soiling index. Another new sampling methodology, which also measures fine particles less than 10 microns and which is still under development, yields results comparable to suspended particulate data.

The 1986 Phytotoxicology Section's annual chemical analysis of silver maple foliage indicated that fluoride, boron and iron values were elevated in proximity to the industrial area and decreased with distance, confirming the industries as a source(s) of these elements. Boron and iron exceeded background values in 1986 at only one station located closest to the industries. In general, the fluoride and iron values at most sites continued to decline in 1986 but, at the same time, boron concentrations were higher than in recent years. Heavy precipitation experienced in 1986 is believed to have played a major role in reducing the levels of iron and fluoride, both by washing the leaves of surface particulates and diluting uptake from soil. Lead, sulphur, zinc, sodium and chloride values were all well within their respective normal concentration ranges, although the concentrations of these elements were frequently higher near the industrial complex. Concentrations of most of the measured parameters have generally decreased since the phytotoxicology surveys began in Hamilton in 1973.

A phytoxicology survey was also conducted near Hamilton Brick Ltd. and detected light to moderate injury to sensitive vegetation (mostly silver maple) due to fluoride emissions. The measured ambient fluoride levels are not a human health concern, however, the plant and its emissions will be investigated.

The Air Resources Branch mobile van survey in 1986 showed that napthalene, total reduced sulphur compounds and oxides of nitrogen were found to be a potential environmental problem in the industrial sector of Hamilton. Measurements of the air quality downwind of Stelco resulted in a maximum half-hour average ground level concentration of 0.47 parts per million (ppm) for oxides of nitrogen. The applicable Ministry Air Quality Standard for this contaminant is 0.25 ppm. Half-hour average concentrations ranging up to 330 micrograms per cubic meter (ug/m^3) of napthalene were detected downwind of the Domtar (Cassidy Works) tar plant. In April of 1987, the Ministry adopted an Air Quality Provisional Guideline of 36 ug/m^3 for napthalene. Half-hour concentrations of total reduced sulphur compounds ranging up to 0.120 ppm were also detected downwind of this Domtar plant. In addition, a universal background concentration of 0.005 ppm for total reduced sulphur compounds was generally detected throughout this sector. The Ministry Provisional Guideline of 0.027 ppm for for total reduced sulphur compounds was developed specifically for the Kraft Pulp Mill industry and therefore is not directly applicable to these data, but it is worth noting that this value was exceeded. A more general guideline has been requested.

Little difference was noted from a similar survey done in 1985.

Data from the previous few years showed small rises and decreases in industrial emissions with corresponding rises and falls in measured suspended particulate levels. This indicates that overall air quality improvements through further industrial abatement might still be achieved to some degree. However, the remaining pollution sources are difficult to control. Work is continuing in order to reduce these emissions through existing Control Orders. There is also a significant influence of long range transport of particulates from outside the city, mainly the U.S., and this effect is visible throughout Southern Ontario. This factor seemed to affect 1986 levels the most.

Dustfall levels throughout the city have not improved at all since 1970 despite huge decreases in industrial process emissions and control efforts by the larger industries within their properties to control fugitive dust, such as the use of chemical sealants, road paving, road washing and landscaping. This indicates that other pollution sources on which no emphasis has yet been placed will also require control wherever possible. These sources can be both industrial and non-industrial in nature, such as blowoff from unpaved areas, excavation, construction, demolition, road traffic and stock piles and related materials handling. Further efforts to reduce fugitive dust emissions should be made by both City and industry.

As mentioned in an earlier section, the Hamilton air monitoring network has been previously expanded to include three new major stations:

- in the east end at Nash/Kentley,
- in the west end on Main Street West/Highway 403,
- on the mountain on Vickers Road near Upper Wentworth.

This expansion was in response to the installation of a new provincial data telemetry system which will allow for all new stations and many existing stations to be telemetered directly to a central computer facility in Toronto, allowing for data retrieval on a real-time basis. Currently, only a fraction of West Central Region continuous monitors are telemetered to Toronto. The remainder of the Region's stations require manual reading of strip charts which causes delays of several months in data availability. The new system will allow for immediate access to data, both in Toronto and in the Hamilton office and will permit remote control and maintenance of instruments, all resulting in a more efficient monitoring program.

A new station has been located closer to downtown in 1987 at Elgin and Kelly Streets. This station now measures the Air Pollution Index in place of the Barton/Sanford location. All of the Barton Street station's automated instruments have been transferred to Elgin/Kelly. However, Barton still operates on a reduced scale for the more important parameters. The new station is less affected by traffic emissions and hence is a more representative site for the Hamilton area as a whole.

Once the new telemetry system has been installed and properly functioning, a new Air Quality Index (AQI) will be added to the current Air Pollution Index which refers to only two pollutants. The new AQI will be a function of six different pollutants, which will form up to eight separate subindices. Concentrations of sulphur dioxide, soiling index, carbon monoxide, nitrogen dioxide, total reduced sulphur and ozone will all be individually converted to the current scale of index numbers with the same advisory or alert levels of 32, 50, 75 and 100. The current API will be retained as one sub-index and will continue to be used for industrial action requests should the API reach 32 or higher. Not all AQI stations will measure all six pollutants and all eight sub-indices but the highest sub-index measured and the pollutant causing it will be reported to the public. In Hamilton, four separate AQIs will be reported for the three new stations and the new downtown API station at Elgin/Kelly. The need for more than one index station in Hamilton has been apparent for some time as air quality can vary widely throughout the city at any given time.

The intent of the new index is to better inform the community about day to day air quality.

7. Acknowledgment

Thanks to the Urban Air Environment Group at McMaster University for providing their suspended particulate data.

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APPENDIX 1

PHYTOTOXICOLOGY ASSESSMENT SURVEY IN THE HAMILTON AREA, 1986

Air Resources Branch
Phytotoxicology Section

By: Dr. W.D. McIlveen

Date: September, 1987.

ARB No.: ARB-065-87-Phyto

Phytotoxicology Assessment Survey in the Hamilton Area, 1986

Introduction

Since 1970, the Phytotoxicology Section of the Ontario Ministry of the Environment has conducted annual surveys of vegetation and soils of the Hamilton area. The purpose of these surveys has been to document the condition of vegetation species and their accumulation of airborne contaminants emitted from the heavy industrial complex located on the south shore of Hamilton Harbour. The present report summarizes the results obtained from the survey conducted in 1986 in relation to earlier investigations.

Survey Outline

The survey in its present format was established in 1973. At that time, eleven permanent sampling stations were established as indicated in Table A. In 1986, two additional stations were added on the north shore of Hamilton Harbour in order to assess the impact of emissions which might traverse the harbour area. All stations are shown in Figure 1.

On August 25, 1986, at each established station foliage samples of silver maple (Acer saccharinum) were collected for chemical analysis. Visual observations of foliage condition were also made at this time.

The samples were brought to the Phytotoxicology laboratory for processing. Each sample was divided into two portions, one of which was washed to remove surface particulate. The samples were then oven-dried, ground in a Wiley-mill and stored in glass bottles. They were then analyzed for fluoride, boron, iron, zinc and lead. In addition the unwashed samples were analyzed for sulphur. All analyses were performed by the Inorganic Trace Contaminants Section of the Ministry of the Environment Laboratory, Resources Road, Toronto.

TABLE A

Station No.	Location	Direction*
1	Beach Blvd. at Burlington Canal	4.4 km NE
2	Beach Blvd. at Renfrew	3.5 km NE
3	Beach Blvd. at former toll booth	3.4 km E
4.	Mead and Dunn Streets	5.0 km SE
5	Craigmiller and Rosslyn Streets	2.3 km S
6	Burlington and Gage Streets	1.3 km S
7	Minto and Bristol Streets	2.3 km SW
8	Eastwood Park	3.2 km W
9	Charlton and Dundurn	7.2 km SW
10	Oakwood Place	9.3 km SW
11	West and Baldwin	12.2 km SW
12	Brighton Beach Park	3.3 km WNW
13	Lasalle Park	4.0 km NNW

*Distance and direction from approximate centre of steel making complex.

Visual Observations

Injury to the maple foliage in 1986 was restricted to light terminal necrosis at Stations 5, 6 and 7 nearest to the industrial complex. Surficial particulate was conspicuous on foliage collected at Station 6. The details of each observation are indicated in Table 1.

Chemical Analysis Results

The results of the chemical analyses are presented in Tables 2 to 7. In addition, certain data are presented in Figures 2

to 4. These were prepared based on data determined as mean values for selected two or three-year intervals which could be compared with 1985 and 1986 values to determine trends with time. The data are from Stations 6 to 11 which lie at increasing distances in a westerly direction from the industrial complex. The pattern for each element is discussed within its respective section below.

Boron:

The concentrations of boron measured in the samples are presented in Table 3. The upper limit of background concentration has only ever been exceeded at Stations 5 and 6 which lie within the industrial zone. In 1986, boron values in both washed and unwashed samples collected at Station 6 (280 and 220 ug/g B respectively) exceeded the background concentration limit of 175 ug/g B. Not only were these the highest values of any stations in 1986, but they were also the highest values recorded since 1977 at this location. Boron values at Stations 5 and 7 were also higher than at the other sites; however, they were within the normal range for vegetation in an urban area.

The washing procedure did not have a consistent effect on the measured boron values, suggesting that most boron was internal to the foliage.

The generally higher boron values measured in 1986 show a reversal in the general trend of decreasing concentrations over time. This pattern is indicated in Figure 3. This figure also shows the decrease in boron concentrations with increasing distance from the industrial zone.

Iron:

The iron concentrations in the maple foliage samples are indicated in Table 4. The data show that the foliage contained above normal (> 1000 ug/g Fe) consistently at Station 6 located nearest to the steel mill complex. The value of 1400 ug/g Fe recorded in 1986 was the lowest encountered at this station since 1978. Unprecedented low values were also recorded at Stations 1, 3, 4, 9 and 11. This pattern did not continue at Stations 7 and 8 where the concentrations of iron were higher than those measured in recent years (Figure 4). At other stations, the apparent trend to lower iron concentrations with time was broken by a slight increase in 1985 as compared with recent years. The information presented in Figure 4 shows that there was a decrease in iron concentrations with distance from the industrial zone.

The generally lower iron values seen in 1986 paralleled the lower fluoride concentrations. The heavier than normal rainfall experienced in 1986 could have been responsible for both the reduced iron content of the foliage as well as the reduced differential in concentration between washed and unwashed samples. This pattern was not consistent in that higher iron concentrations were measured in washed samples compared with unwashed samples in 1986 at Stations 2, 3 and 11. This discrepancy is attributed to inherent sample variability. Also, the absence of rainfall for an extended period prior to the sampling period in 1985 may have contributed to higher iron concentrations in 1985 since particulate would not have been washed from the foliage.

Lead:

The lead concentration of vegetation is shown in Table 5. Since 1980, no samples of maple foliage collected in the Hamilton area contained lead in concentrations considered to be above that of urban background. Up to 1980, elevated lead levels (greater than 60 ug/g Pb) were found at Stations 2, 3 and 6 on two or more occasions. Lead

values found in 1986 were generally lower than in previous years at corresponding locations perhaps reflecting the washing of foliage by the heavy rainfall during 1986. At Station 6, located nearest to the centre of the industrial complex, the lead values were slightly higher than at the remaining stations.

Sulphur:

The sulphur concentrations in the silver maple foliage are presented in Table 6. The concentrations varied widely from year to year at any given station. The sulphur concentrations in samples collected in 1986 were lower than in 1985 at all stations except Stations 7 and 8. No other pattern of sulphur content with respect to time or locations could be determined and nor were any of the 1986 results in excess of the urban guideline.

Fluoride:

Fluoride concentrations in silver maple foliage collected at the sampling stations are shown in Table 2. Prior to 1985, elevated fluoride values (>35 ug/g F) were regularly encountered at a number of stations within or near the industrial area. Foliage collected at those stations nearest the steel mills contained the highest amounts of fluoride. Unwashed foliage samples collected at Station 6 exceeded the limit of background concentrations for fluoride in every year from 1973 to 1985. The remote stations (Stations 9, 10 and 11) all showed background fluoride values except Station 9 in 1977.

The years of higher values included 1976, 1977 and 1979 and to a lesser extent 1973. The highest value measured was 335 ug/g F in the unwashed sample collected in 1977 at Station 6. By contrast the highest value found in 1986 was 31 ug/g F at this same station. Further, normal background concentrations were not exceeded in 1986. In fact, virtually all stations showed a decrease in fluoride values

to a level which were at or below the lowest values obtained over the 14 years in which this study has been carried out.

Washed samples contained only slightly lower amounts of fluoride than unwashed samples in the majority of cases. This indicates that a small portion of the fluoride was present only on the surface of the foliage and could be removed by washing. The relatively small amounts of surficial fluoride on the foliage measured in 1986 is a reflection of the washing action of the frequent precipitation experienced in 1986.

In Figure 2, the data show a clear trend of decreasing fluoride concentrations with distance from the steel mills. At most stations, the highest fluoride concentrations were recorded in the 1976 to 1978 period. The values measured in 1986 indicate that the fluoride concentrations have continued to decline.

Zinc:

The zinc concentration of maple foliage is summarized in Table 7. All values measured were well within the normal range (< 250 ug/g Zn) except in 1979 at Station 6. Station 6 consistently gave the highest zinc measurements of any of the stations thus suggesting some contribution from airborne emissions from the industrial zone. The concentrations of zinc measured in 1985 were generally similar or slightly lower than those measured in recent years but were usually lower than those encountered in the early years of the survey.

Summary

The annual surveillance program to determine whether emissions from the industrial complex at Hamilton were affecting vegetation was continued in 1986. Injury to silver maple foliage was restricted to light terminal necrosis at three stations closest to the industrial complex. From the chemical analyses obtained, it was shown that boron and iron values were elevated in proximity to the

industries and decreased with distance, thereby implicating the industrial complex as a source of these elements. Boron and iron exceeded background values in 1986 at only one station located within the industrial zone. In general, the fluoride and iron values continued to decline in 1986 but at the same time, boron concentrations were higher than in recent years. The heavy precipitation experienced in 1986 is believed to have played a major role in reducing the concentrations of iron and fluoride measured in the foliage by washing particulate material from the surface of the leaves. Lead, sulphur and zinc values were all well within their respective normal concentration ranges although the concentrations of these elements were frequently highest near the industrial complex. Lead and zinc concentrations have generally decreased during the time frame of the surveys carried out in the Hamilton area. Samples of maple foliage collected at two new stations established on the north shore of Hamilton Harbour in 1986 contained some of the lowest values of the respective elements measured in this study. The impact of any emissions from the industrial complex on this area must, therefore, be considered as minimal with respect to vegetation.

Figure 1 Vegetation monitoring stations in the Hamilton area

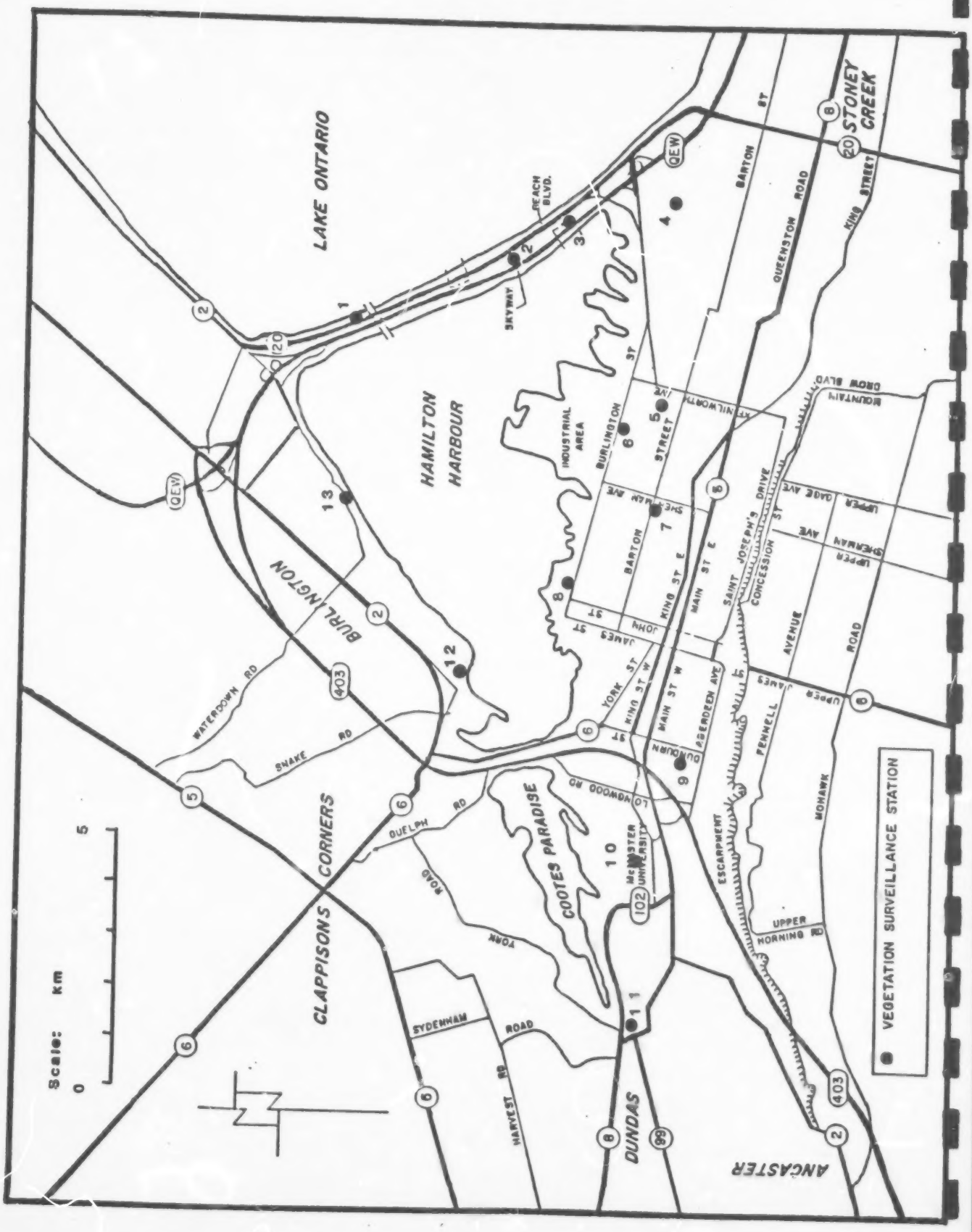


Figure 2

Concentration of Fluoride in Silver Maple Foliage Hamilton Survey

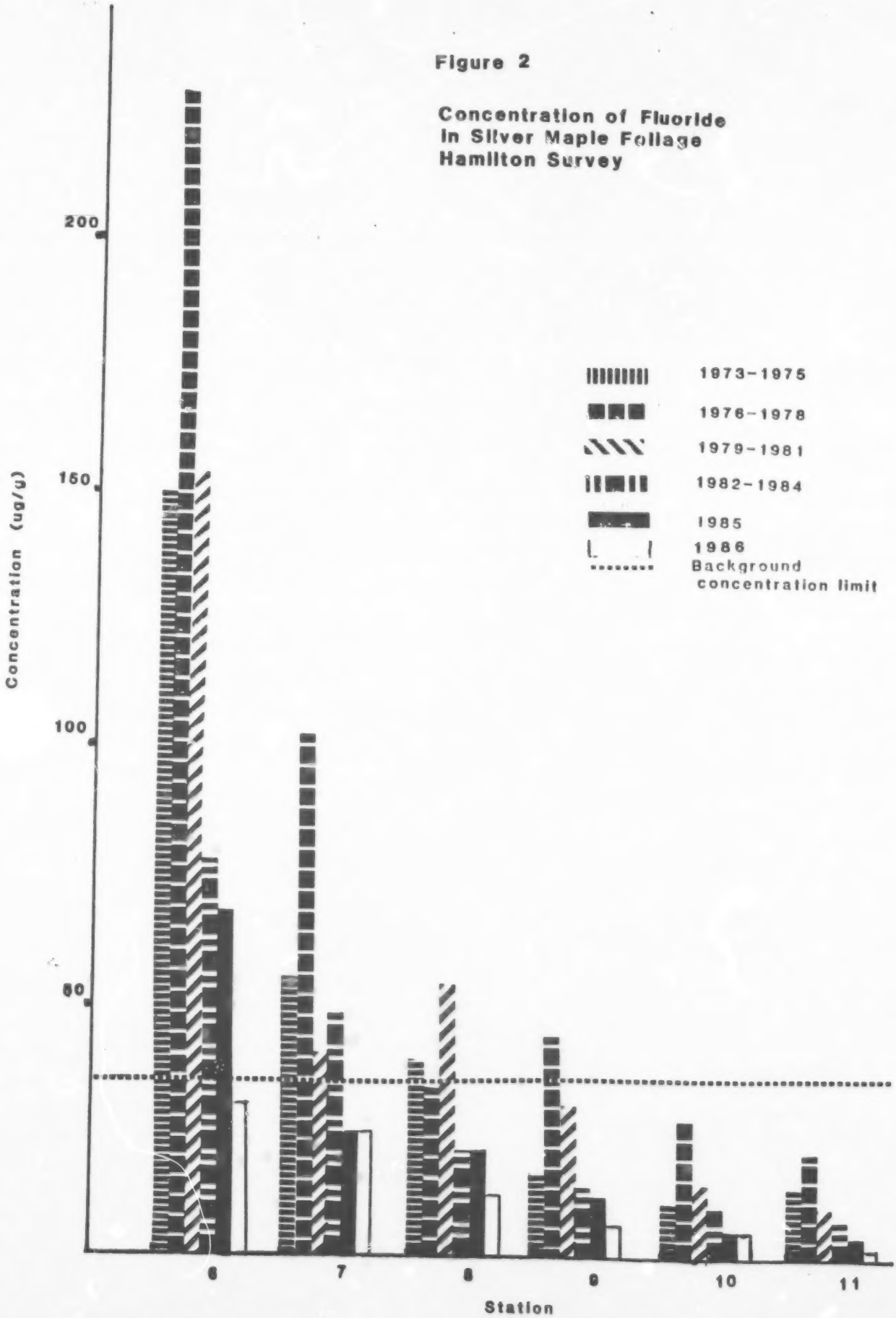
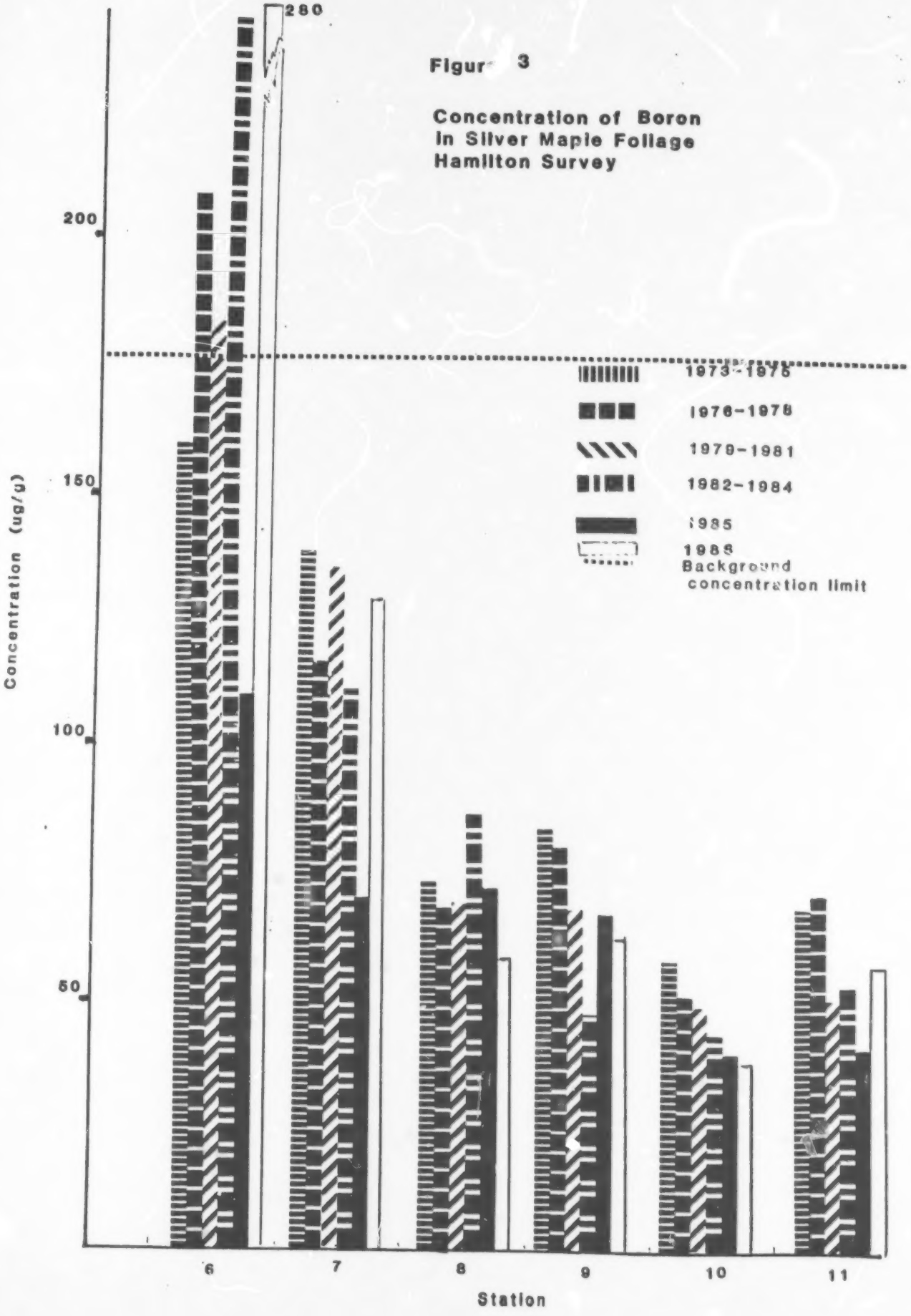


Figure 3

Concentration of Boron
In Silver Maple Foliage
Hamilton Survey



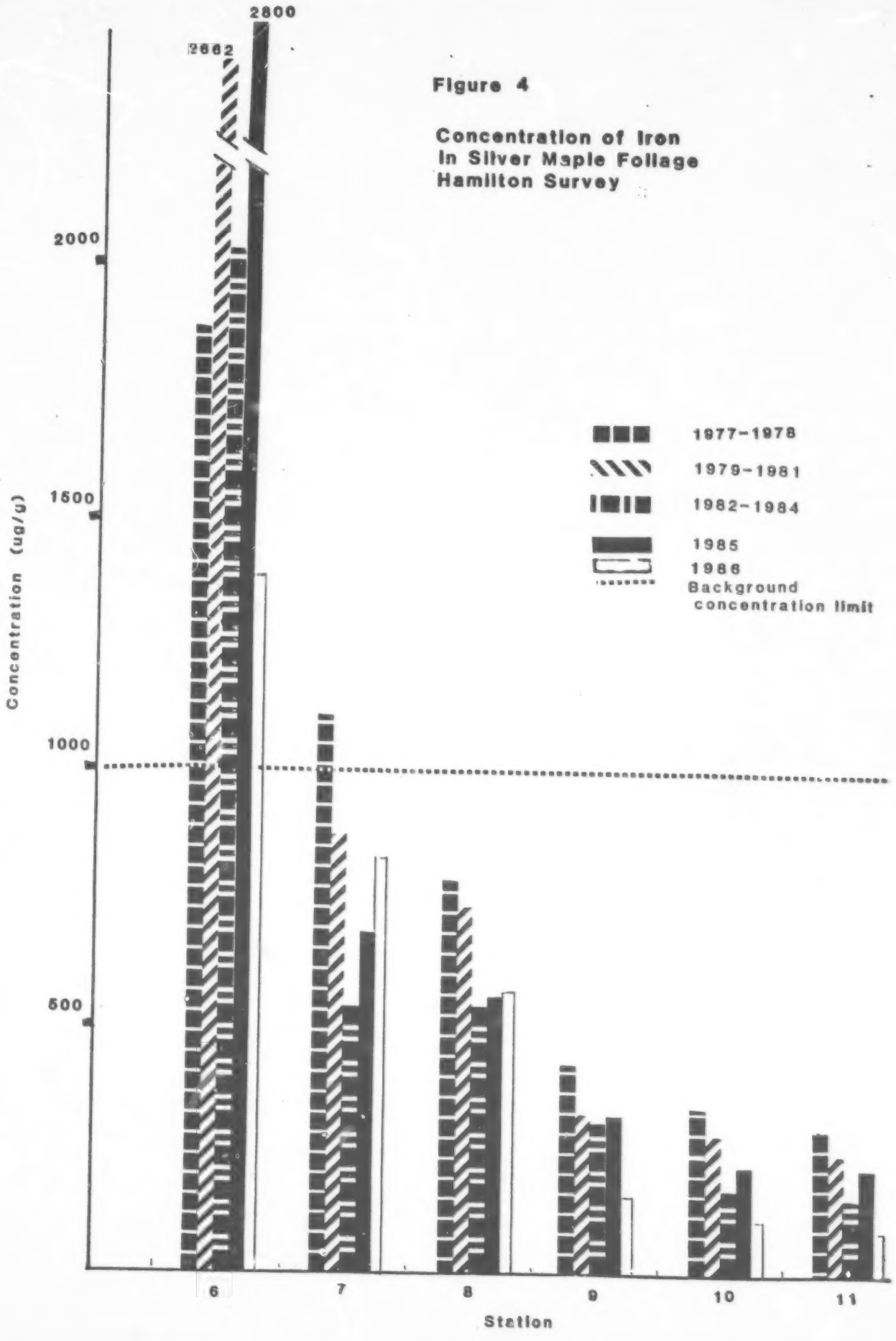


Figure 4

Concentration of Iron in Silver Maple Foliage Hamilton Survey

TABLE 1 - Condition of Foliage of Silver Maple Samples Collected at Sampling Stations in the Hamilton Area - August 25, 1986

Station Number	Condition
1	Trace terminal necrosis
2	Trace terminal necrosis, light discoloration of some leaves
3	Healthy
4	Healthy
5	Light terminal necrosis on young leaves, trace terminal necrosis with light chlorine and some discoloration on older leaves.
6	Light terminal necrosis and light covering of black particulate dust
7	Light moderate terminal necrosis preceded by moderate chlorosis and anthrocyanosis
8	Trace terminal necrosis
9	Healthy
10	Leaf crinkling disease
11	Light disease causing necrosis on some young leaves
12	Healthy.

Necrosis = dead tissue

Chlorosis = yellow appearance of foliage

Anthocyanosis = red or purple discoloration

TABLE 2 - Fluoride Concentrations (µg/g, dry wt.) in Not Washed (NW) and Washed (W) Silver Maple Foliage Collected in Hamilton, 1973-1986.

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	32	22	23	15	19	16	114	52	35	27	21	16	56	50	28	22	23	18	22	10	20	15	29	21	28	15	4	4
2	3.5 NE	130	75	32	43	32	29	96	56	97	68	29	24	112	89	45	28	29	31	51	42	15	16	23	21	21	19	16	14
3	3.4 NE	330	175	61	55	167	53	273	132	179	115	75	59	222	161	67	35	36	29	61	12	34	21	37	26	-	-	11	8
4	5.0 SE	80	45	30	16	26	14	107	49	37	25	20	14	49	28	32	15	25	16	40	22	14	9	21	17	23	12	10	9
5	2.3 S	65	42	68	58	29	21	144	77	110	63	46	22	106	77	212	10	38	37	42	30	26	28	28	22	24	15	11	9
6	1.3 S	177	107	181	140	92	60	243	146	335	191	111	60	203	107	164	135	92	59	42	30	120	48	71	54	70	33	31	17
7	2.3 SW	52	55	72	41	42	38	110	51	141	66	55	27	88	62	32	18	40	29	62	50	61	16	24	16	26	13	26	10
8	3.2 W	45	35	35	16	38	32	46	23	73	45	48	22	49	41	15	18	28	22	36	48	17	8	14	12	21	10	13	8
9	7.2 SW	17	15	21	13	13	11	31	19	40	26	14	11	30	22	10	5	23	16	20	26	11	10	13	11	7	6	7	7
10	9.3 SW	15	12	12	7	3	23	15	7	12	8	9	8	21	14	3	3	22	14	18	10	6	5	9	9	5	4	5	4
11	12.2 SW	15	15	13	9	-	-	26	16	31	24	6	5	15	14	5	3	10	8	12	12	6	5	9	8	4	2	2	2
12	3.3 WNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
13	4.0 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2

Contaminant Guideline: Foliage, NW - 35 ug/g fluoride

*Relative to centre of steel-making complex.

TABLE 3 - Boron Concentrations (µg/g, dry wt.) in Not Washed (NW) and Washed (W) Silver Maple Foliage Collected in Hamilton, 1973-1986.

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	113	138	93	91	108	99	107	103	139	127	83	82	120	118	91	78	81	81	66	66	51	42	50	44	48	44	68	68
2	3.5 NE	106	106	92	103	94	91	82	77	-	-	82	55	70	72	76	74	64	66	46	61	46	45	67	75	54	55	66	52
3	3.4 E	136	136	113	113	82	78	95	77	110	110	71	73	87	78	72	94	70	72	65	55	62	38	75	70	-	-	54	55
4	5.0 SE	82	77	69	65	75	66	63	63	85	78	75	75	53	57	59	58	58	54	46	37	48	44	55	59	59	63	56	61
5	2.3 S	118	118	124	117	309	283	200	166	-	-	239	213	109	110	131	138	119	130	125	120	150	123	96	105	130	120	97	110
6	1.3 S	158	153	139	138	179	161	174	177	290	273	163	155	230	222	138	168	186	187	246	194	217	186	275	193	110	120	280	220
7	2.3 SW	148	128	111	109	154	143	116	104	125	112	107	117	125	111	156	163	128	124	104	108	104	149	127	90	70	72	130	78
8	3.2 W	60	59	79	78	81	75	71	73	78	73	54	53	45	38	57	67	106	84	88	89	84	66	89	82	72	25	59	61
9	7.2 SW	84	80	79	85	90	87	74	70	78	77	90	53	68	66	82	86	60	68	47	42	51	55	42	41	67	71	63	63
10	9.3 SW	50	50	63	55	61	65	65	57	46	39	44	44	62	59	49	42	36	37	39	46	42	42	50	51	40	38	38	34
11	12.2 SW	74	75	62	55			76	69	97	87	39	39	48	50	63	63	41	40	50	49	45	40	64	62	40	37	57	65
12	3.3 WNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	56
13	4.0 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	45

Contaminant Guideline: Foliage, NW - 175 ug/g boron

*Relative to centre of steel-making complex.

TABLE 4 - Iron Concentrations (µg/g, dry wt.) in Not Washed (NW) and Washed (W) Silver Maple Foliage Collected in Hamilton, 1977-1986.

Station No.	Location* km	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	670	440	512	357	987	847	585	680	424	270	566	412	596	307	700	360	950	580	260	230
2	3.5 NE	1390	690	548	415	1110	870	780	555	711	505	679	560	438	319	640	440	690	430	380	450
3	3.4 E	1840	1410	1010	780	2117	1330	970	755	841	425	1160	456	987	623	1040	550	-	-	260	280
4	5.0 SE	620	383	395	303	743	547	715	435	489	325	423	260	377	269	410	270	630	490	270	190
5	2.3 S	1200	467	458	206	1030	757	435	240	587	360	368	229	510	227	320	230	550	360	370	210
6	1.3 S	2370	1840	1370	910	2467	1600	3500	2380	2020	1020	2100	1200	1760	1180	2400	1030	2800	2000	1400	780
7	2.3 SW	1700	730	502	237	1066	837	690	410	880	375	682	540	450	213	450	190	680	410	840	300
8	3.2 W	1130	750	558	333	977	803	610	565	628	415	685	528	522	253	340	220	540	180	560	450
9	7.2 SW	630	350	190	110	480	306	260	160	224	135	416	284	199	181	220	170	300	200	160	110
10	9.3 SW	350	183	165	115	340	213	430	430	94	70	159	140	120	88	180	130	210	170	110	89
11	12.2 SW	403	217	160	92	397	313	200	180	137	90	104	98	151	76	130	110	200	160	93	120
12	3.3 WNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89	70
13	4.0 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	91	75

Contaminant Guideline: Foliage, NW - 1000 ug/g iron

*Relative to centre of steel-making complex.

TABLE 5 - Lead Concentrations (µg/g, dry wt.) in Not Washed (NW) and Washed (W) Silver Maple Foliage Collected in Hamilton, 1973-1986.

Station No.	Location* km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	22	15	20	13	9	8	32	23	19	16	15	11	20	18	14	14	10	6	12	10	13	11	13	7	13	8	7	6
2	3.5 NE	72	47	64	40	21	16	46	34	49	31	26	21	42	40	14	14	20	8	15	11	10	10	10	7	11	7	7	8
3	3.4 E	272	201	57	47	34	25	75	62	53	39	33	24	32	26	14	11	20	9	18	11	17	15	13	7	-	-	5	6
4	5.0 SE	55	31	38	24	19	13	42	26	25	19	16	12	50	30	14	12	14	6	12	8	12	13	11	7	13	10	5	1
5	2.3 S	35	24	35	31	11	7	27	23	33	20	20	11	24	20	12	7	13	10	11	8	8	9	8	6	10	7	7	1
6	1.3 S	79	65	103	72	72	54	86	62	129	87	43	32	67	41	64	43	23	10	30	20	22	23	26	16	32	25	19	13
7	2.3 SW	41	31	38	27	7	4	30	24	40	22	16	9	28	20	12	9	15	7	13	10	8	8	8	3	9	6	10	4
8	3.2 W	50	46	40	29	21	13	38	29	35	23	30	24	32	26	18	18	16	9	14	12	8	9	6	4	7	5	6	5
9	7.2 SW	26	26	25	14	5	1	29	22	24	19	24	9	18	13	10	10	6	4	11	7	6	8	7	5	6	3	2	1
10	9.3 SW	24	37	24	16	4	2	27	15	17	12	8	6	13	11	6	6	3	2	6	4	5	8	3	2	3	2	2	1
11	12.2 SW	27	19	20	14	-	-	28	18	21	14	10	7	21	17	11	11	6	4	5	5	7	9	5	3	4	4	3	2
12	3.3 WNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
13	4.0 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	<1

Contaminant Guideline: Foliage, NW - 60 ug/g lead

*Relative to centre of steel-making complex.

TABLE 6 - Sulphur Concentrations (µg/g, dry wt.) in Not Washed Silver Maple Foliage Collected in Hamilton, 1978-1986.

Station No.	Location* km	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	4.4 NE	0.17	0.29	0.18	0.2	0.20	0.14	0.15	0.18	0.17
2	3.5 NE	0.13	0.19	0.16	0.2	0.13	0.12	0.13	0.19	0.14
3	3.4 E	0.24	0.34	0.21	0.2	0.26	0.19	0.22	-	0.13
4	5.0 SE	0.21	0.23	0.20	0.2	0.19	0.18	0.20	0.22	0.19
5	2.3 S	0.24	0.20	0.16	0.2	0.17	0.17	0.12	0.15	0.12
6	1.3 S	0.21	0.29	0.26	0.4	0.39	0.25	0.25	0.24	0.18
7	2.3 SW	0.27	0.29	0.20	0.2	0.20	0.19	0.16	0.15	0.18
8	3.2 W	0.17	0.22	0.17	0.2	0.23	0.18	0.20	0.16	0.20
9	7.2 SW	0.23	0.25	0.24	0.2	0.25	0.15	0.10	0.22	0.11
10	9.3 SW	0.17	0.21	0.20	0.2	0.18	0.15	0.16	0.19	0.14
11	12.2 SW	0.11	0.20	0.15	0.1	0.15	0.113	0.13	0.15	0.12
12	3.3 WNW	- -	- -	- -	- -	- -	- -	- -	- -	0.15
13	4.0 NNW	- -	- -	- -	- -	- -	- -	- -	- -	0.17

Contaminant Guideline: Foliage, NW - 0.4% sulphur

*Relative to centre of steel-making complex.

TABLE 7 - Zinc Concentrations (µg/g, dry wt.) in Not Washed (NW) and Washed (W) Silver Maple Foliage Collected in Hamilton, 1973-1986.

Station No.	Location[a] km	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
		NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
1	4.4 NE	91	50	51	48	45	43	68	54	50	44	47	52	52	49	50	50	31	30	38	37	42	38	36	34	68	80	70	70
2	3.5 NE	121	117	96	80	118	114	101	80	58	48	61	54	77	84	98	92	83	84	54	61	47	46	71	71	84	92	79	57
3	3.4 E	123	112	116	92	116	103	144	132	121	108	140	133	175	159	102	100	81	75	106	66	85	90	90	84	-	-	71	50
4	5.0 SE	81	65	48	39	30	24	55	40	58	51	58	53	67	60	76	66	59	63	55	48	44	49	60	67	64	82	38	34
5	2.3 S	91	55	109	102	38	31	74	62	69	52	48	39	76	71	64	55	62	64	51	45	52	53	46	47	47	59	48	39
6	1.3 S	170	150	195	175	102	80	193	145	247	222	168	154	317	251	172	147	102	84	113	80	123	188	115	110	140	130	100	71
7	2.3 SW	125	93	75	75	85	44	96	70	101	83	61	49	75	66	58	50	50	40	45	38	52	53	65	40	46	39	49	35
8	3.2 W	93	82	67	54	80	69	72	56	77	59	58	50	78	75	50	48	60	63	59	59	41	37	45	37	45	11	30	33
9	7.2 SW	56	54	60	60	62	54	75	63	69	78	54	57	48	42	70	75	47	41	40	32	38	42	25	24	52	50	32	34
10	9.3 SW	59	69	60	60	66	59	75	67	53	47	57	60	43	41	52	50	45	40	40	49	40	48	66	65	46	56	24	28
11	12.2 SW	69	69	53	40	-	-	94	71	73	65	38	34	56	53	73	80	41	39	55	53	50	50	67	56	44	47	52	52
12	3.3 WNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	23
13	4.0 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	22

Contaminant Guideline: Foliage, NW - 250 ug/g zinc

[a]Relative to centre of steel-making complex.